CONTRIBUTIONS
FROM THE
CUSHMAN FOUNDATION
FOR
FORAMINIFERAL RESEARCH

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Contents

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FOR FORAMINIFERAL RESEARCH

Editor
Frances L. Parker

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155. FORAMINIFERA FROM THE McINTOSH FORMATION (EOCENE) AT McINTOSH LAKE, WASHINGTON[1]

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ABSTRACT

Foraminifera are illustrated and discussed from a lower part of the McIntosh formation exposed within the type area near McIntosh Lake, Washington. The fauna represents the *Amphimorphina californica* assemblage of the *Bulimina* cf. *B. jacksonensis* zone of southwestern Washington. It is similar to faunas from northwestern Washington and western Oregon and compares favorably with the assemblage of Cushman and McMasters from the Llajas formation of McMasters (1933) of California which Laiming considers typical of his B-1A zone of Eocene age in California.

INTRODUCTION

During the course of investigations by the U. S. Geological Survey in the Centralia-Chehalis district, Washington, a sequence of at least 4,000 feet of siltstone, claystone, and sandstone was described and named the McIntosh formation (Snavely *et al.*, 1951). Strata included in the type area of the McIntosh formation crop out immediately east of Tenino, Washington, and are confined largely to T. 16 N., R. 1 W. (figure 1).

West of the type area in the Doty-Minot Peak area, Pease and Hoover (in preparation) have included strata in the McIntosh formation that are somewhat younger than those exposed in the type area.

Four foraminiferal zones were tentatively recognized in the McIntosh formation of the Centralia-Chehalis district and referred to from oldest to youngest as the *Vaginulinopsis vacavillensis* zone, *Amphimorphina californica* zone, *Bulimina* cf. *B. jacksonensis* zone, and *Gyroidina-Uvigerina* zone (Snavely *et al.*, in press). Later studies in southwestern Washington (Rau, in preparation) have established foraminiferal divisions in this part of the stratigraphic sequence that are applicable for a larger area extending some 50 miles west and about 35 miles south of the type area of the McIntosh formation.

In these studies it was found that some of the foraminiferal zones of the Centralia-Chehalis district either do not retain their faunal characteristics or are not definable to the west in the Doty-Minot Peak area, and therefore they were referred to as assemblages. The *Vaginulinopsis vacavillensis* zone of the northwestern part of the Centralia-Chehalis district occurs in interbedded sedimentary and volcanic rocks in the lowermost part of the McIntosh formation. Its fauna also occurs to the west in the Doty-Minot Peak area where the rocks are predominantly volcanic and are referred to the Crescent(?) formation by Pease and Hoover (in preparation). The fauna is known only from a few widely separated localities in the Centralia-Chehalis district and Doty-Minot Peak area, and therefore it is regarded as a stratigraphically significant assemblage, which occurs below the *Bulimina* cf. *B. jacksonensis* zone. The *Amphimorphina californica* zone of the Centralia-Chehalis district was combined with the *Bulimina* cf. *B. jacksonensis* zone because the faunal division between them becomes indefinite west of the Centralia-Chehalis district. However, faunal differences between the upper and lower parts of this combined zone generally remain distinguishable throughout the Centralia-Chehalis district and Doty-Minot Peak area. Rau (in preparation) renamed the *Gyroidina-Uvigerina* zone of the Centralia-Chehalis district the *Uvigerina* cf. *U. yazooensis* zone.

The fauna illustrated and discussed in this report was collected from highway cuts along the south side of McIntosh Lake in secs. 13 and 14, T. 16 N., R. 1 W. (figure 1). This is one of the best exposed and most accessible sections of the

[1]Publication authorized by the Director, U. S. Geological Survey.

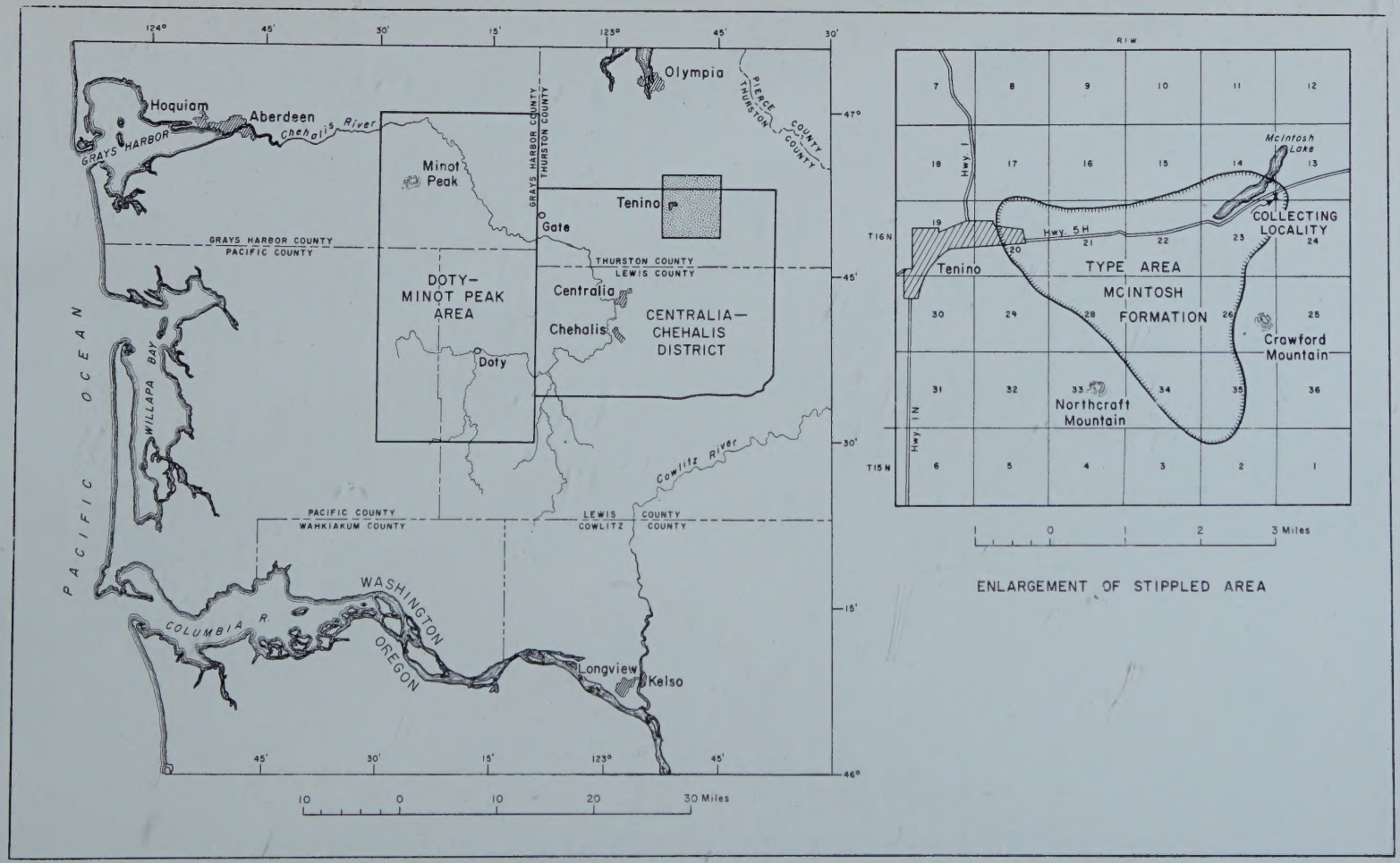


FIGURE 1

Index map of southwestern Washington showing location of the Centralia-Chehalis district, the Doty-Minot Peak area, and the type area of the McIntosh formation.

McIntosh formation within its type area. These strata occur within the lower part of the McIntosh formation and represent the *Amphimorphina californica* assemblage of the *Bulimina* cf. *B. jacksonensis* zone of southwestern Washington.

AGE AND CORRELATION

The Foraminifera from the locality at McIntosh Lake are probably of late middle to early late Eocene age. A substantial number of species are either identical with or at least comparable to those illustrated and discussed by Cushman and McMasters (1936) from McMasters (1933) Llajas formation of California. Laiming (1940) designated the fauna from McMasters' Llajas as typical of his B-1A zone of late Domengine age in California. Of those forms present in both McMasters' Llajas formation and the locality at McIntosh Lake, *Amphimorphina californica* Cushman and McMasters may be the most significant as, according to Laiming (1940), the B-1A zone is characterized principally by the occurrence of this species.

Subsequent to Laiming's studies, *Amphimorphina californica* has been informally reported from strata in California that are believed to be above the B-1A zone. Although the presence of this species may have been controlled largely by ecological conditions, it nevertheless has local stratigraphic significance. In the areas studied by the Geological Survey in southwestern Washington, *Amphimorphina californica* is known only from the lower part of the McIntosh formation which is referred to the *Bulimina* c[f]. *B. jacksonensis* zone of southwestern Washington. The presence of *Clavulinoides* sp., *Nodosaria latejugata* Gümbel, and *Baggina teninoensis* Rau, n.sp. further substantiates the local stratigraphic position of this fauna as these forms are not known elsewhere in southwest Washington above the *Bulimina* cf. *B. jacksonensis* zone.

All foraminiferal faunas collected from beds stratigraphically below those exposed at McIntosh Lake best compare with the faunas of Laiming's B [not B-1A] zones, and those faunas collected from strata above these beds are most nearly like those of Laiming's A zones of California. Therefore, it is suggested that the foraminiferal fauna from the McIntosh formation exposed at McIntosh Lake occupies a stratigraphic position similar to that of Laiming's B-1A zone of Eocene age.

Foraminiferal assemblages similar to that from the outcrops at McIntosh Lake have been collected from the Yamhill formation (Baldwin *et al.*, 1955) of northwestern Oregon, from beds exposed at Sacchi Beach on the Oregon coast about 3 miles south of Cape Arago, and from siltstone below the Lyre formation (Brown *et al.*, in press) exposed in the stream bed of the Lyre River in the northern part of the Lake Crescent quadrangle, Olympic Peninsula, Washington. These assemblages are believed to occupy a stratigraphic position similar to that of Laiming's B-1A zone in California.

FORAMINIFERA

In view of the stratigraphic significance of the assemblage from the type area of the McIntosh formation, representative specimens of the complete fauna are figured and discussed. Several forms are represented by specimens too poorly preserved and too few to be completely identified, but illustrations of them may be useful in future biostratigraphic studies of the Tertiary sequence of the area.

All specimens are from dark-gray siltstone exposed in a road cut along State Highway 5-H south of McIntosh Lake and 4½ miles east of the city center of Tenino, Washington, on section line 400 feet N. of the southeast corner of sec. 14, T. 16 N., R. 1 W., W.M. (see insert fig. 1).

Family TOLYPAMMINIDAE

Genus **Involutina** Terquem, 1862

Involutina sp.

Plate 14, figure 3

A few poorly preserved specimens, of which the most nearly complete is figured, are referred to *Involutina* Terquem rather than to *Ammodiscus* Reuss in accordance with recent emendations by Loeblich and Tappan (1954).

Related forms recorded from Washington State are *Ammodiscus coombi* Beck (Beck, 1943) from the Cowlitz formation of Eocene age and *Ammodiscus* cf. *A. incertus* (d'Orbigny) (Rau, 1951) from beds of Oligocene age.

Dimensions of figured specimen.—Length 0.94 mm., width 0.62 mm., thickness 0.23 mm.
Figured specimen.—USNM, 547620.

Family LITUOLIDAE

Genus **Haplophragmoides** Cushman, 1910

Haplophragmoides? sp.

Plate 14, figure 5

A few badly distorted arenaceous specimens display characteristics of the genus *Haplophragmoides*. The available material suggests that the tests may have been rather broad with five or six chambers in the last whorl. The walls are composed chiefly of cement with a minor amount of coarse arenaceous material. Apertures and other significant features are completely obscured by distortion, and it is with reservation that these specimens are referred to the genus *Haplophragmoides*. The best preserved specimen of the collection is figured.

Dimensions of figured specimen.—Length 0.76 mm., width 0.48 mm., thickness 0.54 mm.
Figured specimen—USNM, 547621.

Genus **Cyclammina** H. B. Brady, 1876

Cyclammina aff. **C. simiensis** Cushman and McMasters

Plate 14, figures 10, 11

Several specimens are most nearly like *C. simiensis* Cushman and McMasters (1936). They are somewhat compressed with 10 to 12 chambers in the last whorl. The walls are composed of fine arenaceous grains with a large amount of cement. They differ from the types of *C. simiensis* in that the test is more compressed and the sutures are more nearly straight. Preservation is such that apertural features cannot be determined.

Dimensions of figured specimen.—Length 1.45 mm., width 1.00 mm., thickness 0.34 mm.
Figured specimen—USNM, 547622.

Family TEXTULARIIDAE

Genus **Textularia** Defrance, 1824

Textularia? sp.

Plate 14, figure 4

A single poorly preserved specimen may belong to the genus *Textularia*. It is extremely compressed, perhaps as a partial result of distortion. The apertural end is broad and nearly flat, forming sharp angles with the periphery. Its periphery tapers uniformly to a nearly pointed initial end. The sutures are strongly limbate and chambers are numerous; 18 were counted in the adult portion of the test.

A comparison of this specimen with type material of the Cushman collection shows that it has some of the characteristics of *T. marielensis* Lalicker and Bermudez (1938). However, it does not have peripheral spines and is more compressed than *T. marielensis*.

Dimensions of figured specimen.—Length 0.58 mm., width 0.66 mm., thickness 0.13 mm.
Figured specimen.—USNM, 547623.

Family VERNEUILINIDAE

Genus **Clavulinoides** Cushman, 1936

Clavulinoides sp.

Plate 14, figures 1, 2

A few specimens display the essential characteristics of the genus *Clavulinoides*. The final chambers of the complete and apparently mature specimens are uniserially arranged with the aperture terminal to subterminal. Small, probably immature specimens and broken specimens without final chambers are indistinguishable from *Gaudryina coalingensis*, particularly *G. coalingensis alata* Israelsky (1951). The complete and probably mature specimens compare favorably with forms figured as *Clavulinoides* sp. by Graham and Classen (1955) and Cushman and Siegfus (1942).

Dimensions of figured specimen.—Length 0.74 mm., width 0.40 mm., thickness 0.37 mm.
Figured specimen.—USNM, 547624.

Family MILIOLIDAE

Genus **Quinqueloculina** d'Orbigny, 1826

Quinqueloculina sp.

Plate 14, figure 7

The genus *Quinqueloculina* is represented by a single fragmentary specimen.

Dimensions of figured specimen.—Length 0.84 mm., width 0.49 mm., thickness 0.41 mm.

Figured specimen.—USNM, 547625.

Genus **Sigmoilina** Schlumberger, 1887

Sigmoilina cf. **S. tenuis** (Czjzek)

Plate 14, figure 6

A single incomplete specimen of *Sigmoilina* is comparable with those figured and referred to as *Sigmoilina tenuis* (Czjzek) by Cushman (1946). The test is compressed with a distinctly necked aperture. It differs from *S. tenuis* in that its breadth is greater proportionate to its length, and it is therefore tentatively referred to Czjzek's species.

Dimensions of figured specimen.—Length 0.33 mm., width 0.22 mm., thickness 0.07 mm.

Figured specimen.—USNM, 547626.

Family LAGENIDAE

Genus **Robulus** Montfort, 1808

Robulus holcombensis Rau

Plate 14, figures 15, 16

Cristellaria rotulata Hanna and Hanna [not Lamarck], Washington Univ. (Seattle). Publ. in Geol., vol. 1, no. 4, 1924, p. 61, pl. 13, figs. 14, 19, 20.

Robulus inornatus Cushman and Schenck [not d'Orbigny], Univ. Calif. Publ. in Geol., vol. 17, 1928, p. 307, pl. 42, figs. 3a, b.—Beck, Journ. Pal., vol. 17, 1943, p. 595, pl. 104, figs. 1-4, 10, 14.—Detling, *loc. cit.*, vol. 20, 1946, p. 353, pl. 47, figs. 4, 5.—Cushman, Stewart, and Stewart, Oregon State Dept. Geol. and Mineral Industries, Bull. 36, pt. 3, 1947, p. 60, pl. 7, figs. 3a, b; pt. 4, p. 74, pl. 11, figs. 6a, b; pt. 5, p. 97, pl. 13, figs. 2a, b.

Robulus holcombensis Rau, Journ Pal., vol. 25, 1951, p. 431, pl. 63, figs. 14-17.

This species was erected by the writer to include those forms from the Pacific Northwest which have been referred to *Robulus inornatus* (d'Orbigny) but are seemingly distinct from d'Orbigny's type. It is a common species in the present material.

The types are from rocks of Eocene and Oligocene age in the Willapa Valley, Pacific County, Washington. Other forms considered conspecific are known from the Cowlitz formation of Eocene age, Lewis County, Washington; the Coaledo and Helmick formations of Eocene age and the Bastendorf shale of Eocene and Oligocene age in Oregon.

Dimensions of figured specimen.—Length 0.75 mm., width 0.65 mm., thickness 0.42 mm.

Figured specimen.—USNM, 547627.

Genus **Dentalina** d'Orbigny, 1826

Dentalina colei Cushman and Dusenbury

Plate 14, figures 12, 17

Vaginulina legumen (Linné), var. *elegans* Cole [not d'Orbigny], Bull. Am. Pal., vol. 14, no. 51, 1927, p. 21, pl. 3, figs. 10, 11.

Dentalina colei Cushman and Dusenbury, Contr. Cushman Lab. Foram. Res., vol. 10, pt. 3, 1934, p. 54, pl. 7, figs. 10-12.—Parr, Journ. Roy. Soc. W. Australia, vol. 24, 1937, p. 76, pl. 1, fig. 8.—Toulmin, Journ. Pal., vol. 15, 1941, p. 584, pl. 79, fig. 12.—Beck, *loc. cit.*, vol. 17, 1943, p. 598, pl. 105, fig. 18.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 20, pt. 2, 1944, p. 37, pl. 5, figs. 25-28.—Cushman and Todd, *op. cit.*, vol. 22, pt. 2, 1946, p. 49, pl. 8, fig. 2,

A number of specimens compare in essentially all respects with the holotype of *D. colei* Cushman and Dusenbury. The test is very slightly arcuate with the chambers almost without inflation and sutures nearly flush with the surface. The aperture is prominent but not strongly produced and always located toward the concave side of the arcuate test.

Dentalina colei Cushman and Dusenbury was described from the Poway conglomerate of Eocene age in California. It has since been widely recorded. In rocks of Eocene age it is recorded from Mexico, Alabama, New Jersey, and Washington; and in rocks of Paleocene age from Alabama and Arkansas.

Dimensions.—Figured specimen 12, length 1.28 mm., width 0.27 mm.; figured specimen 17, length 0.87 mm., width 0.23 mm.

Figured specimens.—USNM, 547628.

Dentalina cf. **D. consobrina** d'Orbigny

Plate 14, figures 13, 14

A few fragmentary specimens are best compared with *Dentalina consobrina* d'Orbigny.

Numerous records of *D. consobrina* d'Orbigny are known from both North America and abroad ranging through much of the Tertiary. In Cali-

fornia the species is recorded from the Llajas formation of McMasters (1933) and the Poway conglomerate of Eocene age and from rocks of Eocene age near Coalinga, California. It is also known from the Bastendorf shale of Eocene and Oligocene age in Oregon. See Ellis and Messina (1940) for additional references to this species.

Dimensions.—Figured specimen 13, length 0.91 mm., width 0.20 mm.; figured specimen 14, length 0.96 mm., width 0.24 mm.

Figured specimens.—USNM, 547629.

Dentalina jacksonensis (Cushman and Applin)

Plate 14, figures 8, 9

Nodosaria jacksonensis Cushman and Applin, Bull. Amer. Assoc. Petr. Geol., vol. 10, 1926, p. 170, pl. 7, figs. 14-16.—Cushman, Journ. Pal., vol. 1, 1927, p. 153, pl. 24, fig. 3.—Cole, Bull. Amer. Pal., vol. 14, no. 53, 1928, p. 208, pl. 3, fig. 12.

Dentalina jacksonensis (Cushman and Applin) Cushman, U. S. Geol. Surv. Prof. Paper 181, 1935, p. 20, pl. 8, figs. 7-9.—Cushman and McMasters, Journ. Pal., vol. 10, 1936, p. 511, pl. 75, figs. 3-5.

A few specimens with somewhat globular chambers and a spined initial end compare well with the type specimen of *D. jacksonensis* (Cushman and Applin).

This species was described from rocks of Eocene age in Texas. It has since been recorded from rocks of Eocene age in South Carolina, Georgia, Alabama, Mexico, and McMasters Llajas formation of California.

Dimensions.—Figured specimen 8, length 1.15 mm., width 0.31 mm.; figured specimen 9, length 1.15 mm., width 0.34 mm.

Figured specimens.—USNM, 547630.

Genus **Nodosaria** Lamarck, 1812

Nodosaria latejugata Gümbel

Plate 14, figures 18-21

Nodosaria latejugata Gümbel, K. bayer. Akad. Wiss. München, Cl. 2, Abh., Bd. 10, 1868, p. 619, pl. 1, fig. 32.—Cushman and Hanna, M. A., San Diego Soc. Nat. Hist., Trans., vol. 5, 1927, pp. 52-3, pl. 5, figs. 1-3.—Cushman and Hanna, G. D., California Acad. Sci., Proc., ser. 4, vol. 16, 1927, p. 212, pl. 13, figs. 15-17.—Cushman and McMasters, Journ. Pal., vol. 10, 1936, p. 512, pl. 75, figs. 11, 12.—Graham and Classen, Contr. Cushman Found. Foram. Res., vol. 6, pt. 1, 1955, p. 16, pl. 2, figs. 33, 34.

Fragmentary specimens of both the supposedly microspheric and megalospheric forms of this species occur in the present assemblage. Although this species is recorded from many stratigraphic horizons throughout the world its known occurrence in southwest Washington is no higher than the *Bulimina* cf. *B. jacksonensis* zone.

The type was described and illustrated from the Eocene of Bavaria and has since been recorded from numerous localities abroad. It is also a well known species in rocks of Eocene age of both the east and west coasts of North America.

Dimensions.—Figured specimen 18 (fragmentary), length 0.95 mm., width 0.44 mm.; figured specimen 19 (fragmentary), length 0.94 mm., width 0.64 mm.; figured specimen 20 (fragmentary), length 0.95 mm., width 0.63 mm.; figured specimen 21 (fragmentary), length 1.15 mm., width 0.48 mm.

Figured specimens.—USNM, 547631.

Genus **Pseudoglandulina** Cushman, 1929

Pseudoglandulina conica (Neugeboren)

Plate 15, figures 1, 2

Glandulina conica Neugeboren, Siebenburg, Ver. Naturwiss. Verh. Mitt., Jahrg. 1, 1850, p. 51, pl. 1, figs. 5a, b.

Glandulina radicula Cole [not *Nautilus radiculus* Linné], Bull. Amer. Pal., vol. 14, no. 51, 1927, p. 17, pl. 3, figs. 6, 7.

Pseudoglandulina conica Cushman and Barksdale, Contr. Dept. Geol. Stanford Univ., vol. 1, no. 2, 1930, p. 65, pl. 12, figs. 1-3.—Beck, Journ. Pal., vol. 17, 1943, p. 599, pl. 105, fig. 12.

The collection contains a few probably immature specimens of this species. Additional specimens have also been collected from other localities in the McIntosh formation, some of which display typical mature features. A form referred to as *Pseudoglandulina*(?) sp. by Cushman and McMasters (1936) appears similar to the present immature representative of *P. conica*.

This form was originally illustrated and described as *Glandulina conica* by Neugeboren from the Tertiary of Rumania. It has since been recorded from several other European Tertiary localities. It is also known from the Martinez formation of Paleocene age in California and

the Cowlitz formation of Eocene age in Washington. Cushman and McMasters' form is from McMasters' (1933) Llajas formation of Eocene age in California.

Dimensions of figured specimen.—Length 0.58 mm., width 0.37 mm.

Figured specimen.—USNM, 547632.

Pseudoglandulina cf. **P. turbinata** Detling

Plate 15, figures 3, 4

The last formed chamber of this form constitutes most of the length of the test. The apertural and initial angles together with the general shape of the test is similar to *P. turbinata* Detling (1946, p. 354, pl. 48, fig. 8). However, Detling's type is slightly larger than the specimen in question.

Dimensions of figured specimen.—Length 0.43 mm., width 0.38 mm.

Figured specimen.—USNM, 547633.

Family HETEROHELICIDAE

Genus **Amphimorphina** Neugeboren, 1850

Amphimorphina californica Cushman and McMasters

Plate 15, figures 6-10

Amphimorphina californica Cushman and McMasters, Journ. Pal., vol. 10, 1936, p. 513, pl. 75, figs. 21-25.

This species is common in the present assemblage and has been collected from other outcrops of the lower part of the McIntosh formation. Although it may have ecologic implications, it is thus far regarded in southwestern Washington as stratigraphically significant. In the type area of the McIntosh formation it has been found only in the lower part and has not been found above or below the *Bulimina* cf. *B. jacksonensis* zone of southwestern Washington. This species has also been collected from the Yamhill formation of northwest Oregon and certain siltstones in northwest Washington. Both of these localities are believed to occupy a stratigraphic position similar to that of the McIntosh formation of southwest Washington. The types are from the Llajas formation of McMasters (1933) of Eocene age in California.

Dimensions.—Figured specimen 6 (fragmentary), length 0.78 mm., width 0.37 mm., thickness 0.20 mm.; figured specimen 7 (fragmentary), length 1.15 mm., width 0.32 mm., thickness 0.22 mm.; figured specimen 8 (fragmentary), length 1.53 mm., width 0.41 mm., thickness 0.30 mm.; figured specimen 9 (fragmentary), length 0.95 mm., width 0.30 mm., thickness 0.17 mm.; figured specimen 10 (fragmentary), length 0.85 mm., width 0.34 mm., thickness 0.28 mm.

Figured specimens.—USNM, 547634.

Family BULIMINIDAE

Genus **Bulimina** d'Orbigny, 1826

Bulimina corrugata Cushman and Siegfus

Plate 15, figure 5

Bulimina corrugata Cushman and Siegfus, Contr. Cushman Lab. Foram. Res., vol. 11, 1935, pp. 92, pl. 14, figs. 7a, b.—Graham and Classen, Contr. Cushman Found. Foram. Res., vol. 6, pt. 1, 1955, p. 19, pl. 3, fig. 17.

This species has been recorded from several localities, but on the basis of a comparison of the available illustrations together with paratypes of the species, the specimens in question best compare with the types of this species from the Kreyenhagen shale of California and specimens collected from shales near Woodside, California (Graham and Classen, 1955).

Studies thus far in western Washington have shown this species to be of stratigraphic significance in that it has not been found above the *Bulimina* cf. *B. jacksonensis* zone of southwest Washington or its probable equivalent in surrounding areas.

Dimensions of figured specimen.—Length 0.46 mm., width 0.28 mm., thickness 0.24 mm.

Figured specimen.—USNM, 547635.

Bulimina cf. **B. guayabalensis** Cole var. **ampla** Cushman and Parker

Plate 15, figure 14

A few smooth *Bulimina* are best compared with Cushman and Parker's variety (1947, p. 96, pl. 22, fig. 13). However, owing to the small number of specimens and their state of preservation, only a tentative comparison can be made at this time.

The type of this variety is from shale of Eocene age, exposed on the north side of Mt. Diablo, California.

Dimensions of figured specimen.—Length 0.80 mm., width 0.59 mm., thickness 0.54 mm.

Figured specimen.—USNM, 547636.

Family ROTALIIDAE

Genus **Gyroidina** d'Orbigny, 1826

Gyroidina sp.

Plate 15, figures 21-23

The genus *Gyroidina* is represented in the present collection by a few specimens too poorly preserved for specific identification. *Gyroidina soldanii octocamerata* Cushman and G. D. Hanna (1927, p. 223, pl. 14, figs. 16-18) and a form comparing with *G. simiensis* Cushman and McMasters (1936, p. 514, pl. 76, figs. 3a-c) are known from other localities of the McIntosh formation in southwestern Washington.

Dimensions of figured specimen. — Diameter 0.45 mm., thickness 0.32 mm.

Figured specimen.—USNM, 547638.

Genus **Eponides** Montfort, 1808

Eponides cf. **E. yeguaensis** Weinzierl and Applin

Plate 15, figures 18-20

A few specimens are best compared with *Eponides yeguaensis* Weinzierl and Applin. Although the present specimens can only be tentatively compared with *E. yeguaensis* Weinzierl and Applin, others from additional localities of the McIntosh formation seem identical to those figured by both Cushman and McMasters (1936) from McMasters' Llajas formation of California and Beck (1943) from the Cowlitz formation of Washington.

Dimensions of figured specimen. — Diameter 0.69 mm., thickness 0.41 mm.

Figured specimen.—USNM, 547639.

Genus **Baggina** Cushman, 1926

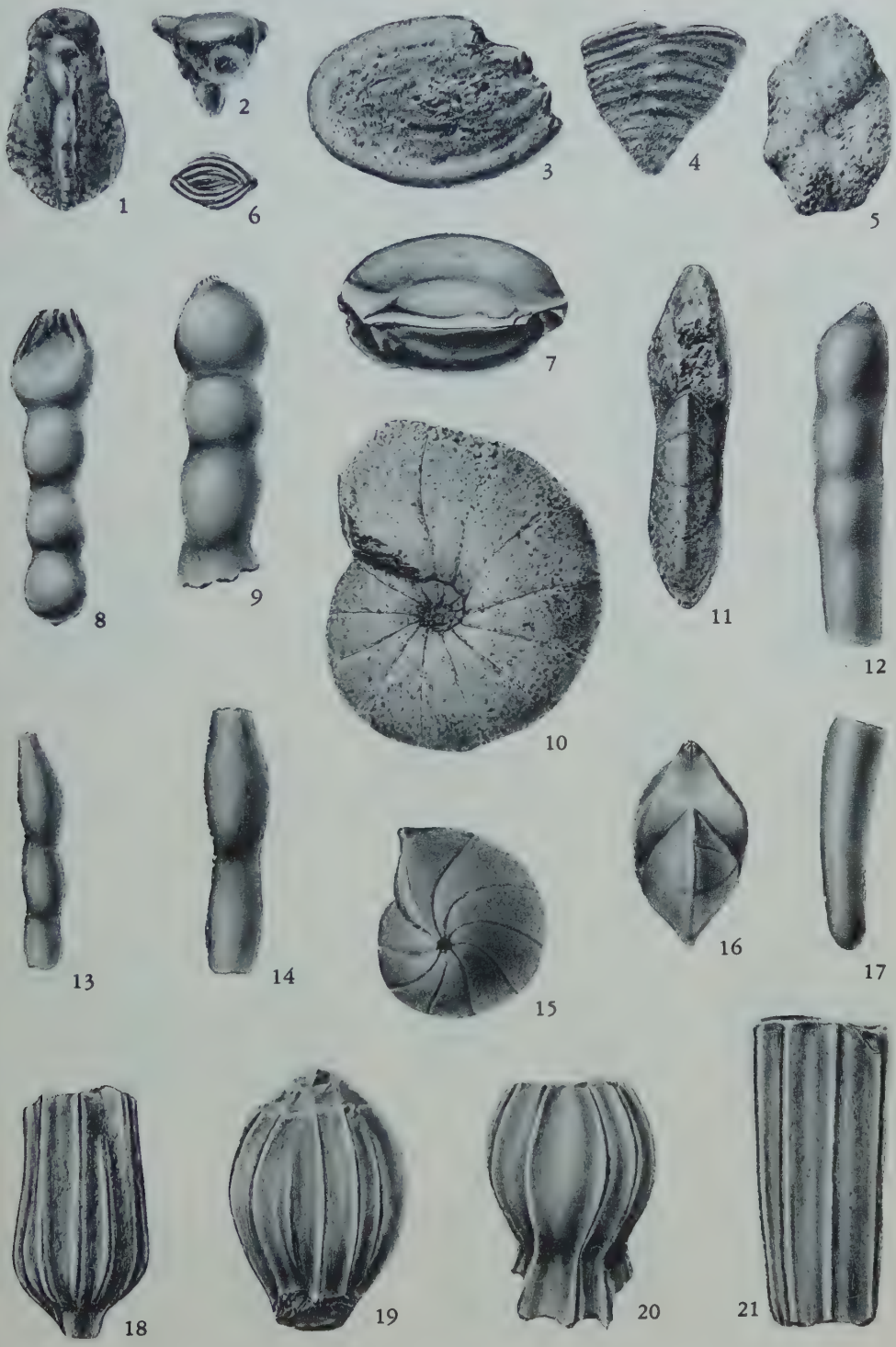
Baggina teninoensis Rau, n. sp.

Plate 15, figures 24, 25

Test subglobular, dorsal side somewhat flattened, ventral side strongly convex and slightly umbilicate, greatest breadth across center of test, periphery broadly rounded; chambers moderately inflated, five in adult whorl, increasing uniformly in size as added, last one forming approximately one-third of the area of the test; sutures indistinct between early chambers, distinct and somewhat depressed between later ones, only slightly curved; walls smooth, very finely

EXPLANATION OF PLATE 14

All specimens are from dark-gray siltstone exposed in a road cut along State Highway 5-H south of McIntosh Lake 4½ miles east of the city center of Tenino, Washington. All figures X40.



Rau: Washington Eocene Foraminifera

Rau: Washington Eocene Foraminifera

and closely perforate; aperture a long slitlike opening at the base of the last formed chamber extending from the ventral umbilicate region to the periphery, usually with coarse dentitions on the margin of the early chambers at the base of aperture.

Length of holotype.—0.54 mm., width 0.48 mm., thickness 0.41 mm.

This species is rather common in the lower part of the McIntosh formation. It resembles *Baggina washingtonensis* Rau (1948, p. 779, pl. 119, figs. 24-27) from Miocene strata of Washington, *B. californica* Cushman (Cushman and Todd, 1944, p. 101, pl. 15, fig. 15) from the Miocene of California, and *B. totomiensis* Makiyama (*ibid.*, p. 103, pl. 16, fig. 7) from the Pliocene of Japan. It differs from all these forms in that it is less highly trochoid; it is smaller than *B. washingtonensis* and *B. totomiensis;* and the last formed chamber constitutes a smaller part of the surface of the test than does that of *B. totomiensis.*

This species has been collected from several localities in the McIntosh formation but is not known from strata above the *Bulimina* cf. *B. jacksonensis* zone of southwest Washington. It is also present in the stratigraphically lower *Vaginulinopsis vacavillensis* assemblage, occurring in sedimentary strata interbedded in volcanic rocks.

Holotype.—USNM, 547641.

Family CASSIDULINIDAE

Genus **Alabamina** Toulmin, 1941

Alabamina sp.

Plate 15, figures 15-17

Although sutural details are not preserved on the present specimens, apertural characteristics compare with those of the genus *Alabamina.* This form has been found in other collections from the McIntosh formation and is a characteristic element in the faunas of the formation.

Dimensions of figured specimen. — Diameter 0.38 mm., thickness 0.23 mm.

Figured specimen.—USNM, 547640.

Family ANOMALINIDAE

Genus **Cibicides** Montfort, 1808

Cibicides cf. **C. warreni** Cushman and R. E. and K. C. Stewart

Plate 15, figures 11-13

A few specimens are best compared with *C. warreni* Cushman and R. E. and K. C. Stewart (1947, p. 104, pl. 13, fig. 11). It is described from the Helmick formation of Oregon of Eocene age and is also recorded from the Toledo formation of Oregon, of Eocene and Oligocene age. In addition, it has been collected by the writer from a number of localities in Washington, all of Eocene age.

Dimensions of figured specimen.—Length 0.60 mm., width 0.51 mm., thickness 0.22 mm.

EXPLANATION OF PLATE 15

All specimens are from dark-gray siltstone exposed in a road cut along State Highway 5-H south of McIntosh Lake 4½ miles east of the city center of Tenino, Washington. All figures X40.

Figured specimen.—USNM, 547637.

Cibicides sp.

Plate 15, figures 26-28

A single specimen belonging to the genus *Cibicides* has a thin, almost plano-convex and coarsely perforate test. The sutures are limbate and the aperture is a slitlike opening extending back on the inner margin of the last 3 or 4 chambers.

Dimensions of figured specimen. — Diameter 0.49 mm., thickness 0.18 mm.

Figured specimen.—USNM, 547642.

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH

VOLUME VII, PART 3, JULY, 1956

156. CERTAIN SMALLER BRITISH PALEOCENE FORAMINIFERA

PART I. NONIONIDAE, CHILOSTOMELLIDAE, EPISTOMINIDAE, DISCORBIDAE, AMPHISTEGENIDAE, GLOBIGERINIDAE, GLOBOROTALIIDAE, AND GÜMBELINIDAE

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ABSTRACT

Thirty-four species and varieties are described, including two new genera, eight new species and one new variety, from the Thanet Beds of East Kent in the United Kingdom. The Thanetian Nonionidae are shown to possess granular test walls. Two species resembling *Nonion* but radiate hyaline with multiple foramina are placed in a new genus, *Protelphidium,* genotype *Protelphidium hofkeri,* n.sp. This new genus can be regarded as a link between *Nonion* on the one hand and *Elphidiella* and *Elphidium* on the other. *Epistominella vitrea* Parker and *Alabamina obtusa* (Burrows and Holland) are shown to be different in wall structure. It is possible that the genera *Epistominella* and *Alabamina* are less closely related than has been considered. Investigation of wall structure reveals complex relations within the Discorbidae. A new genus *Hollandina,* genotype *Hollandina pegwellensis,* n.sp., has been set up within the Anomalininae. In *Hollandina pegwellensis,* as in many of the other species described, a close relation is found between proloculus size and the number of chambers in each whorl. Care is taken to distinguish between the number of chambers present in the last complete whorl and the number of chambers visible at the periphery. The pelagic species recovered emphasize the upper Paleocene age of the formation.

INTRODUCTION

Scope of the paper.—This paper represents part of the results of a taxonomic and stratigraphic revision of the foraminiferal fauna of the Thanet Beds of Kent in the United Kingdom. Thirty-four of the species recovered during the course of the work are described here while the rest of the fauna will be described in subsequent papers. A separate paper will also be published on the stratigraphical and ecological significance of the fauna.

Previous work.—H. Burrows and R. Holland (1897) in their pioneer work on the microfauna recorded three, or possibly four, of the species described below. Of these, *Nonionina depressula,* interpreted by the authors in Brady's sense, is renamed *Protelphidium hofkeri,* n.sp. and made the type of a new genus, while *Pulvinulina exigua* var. *obtusa* Burrows and Holland is renamed *Alabamina obtusa.* The form listed by these authors as *Truncatulina haidingerii* (d'Orbigny) is probably *Hollandina pegwellensis,* n.sp., n.gen. In addition the specimen listed as *Globigerina bulloides* d'Orbigny is possibly *Globigerina triloculinoides* Plummer.

Sections sampled.—Samples for the foraminiferal study were taken along the southern outcrop of the Thanet Beds in the Thames Basin from Pegwell Bay and Woodnesborough in East Kent to Sutton and Cheam in Surrey (Figure 1).

According to previous authors these deposits are of middle or lower, upper Paleocene age—in the zone of *Pholadomya konincki* Nyst and *Cyprina morrisi* (J. de C. Sow), and equivalent to the lower Landenian of the Netherlands. (Prestwich, 1888 and Stamp, 1921). The Foraminifera recovered during the course of the present work emphasize the upper Paleocene age of the formation, including pelagic species typical of the upper Paleocene of the south-eastern United States and of the Middle East. (Haynes, 1955).

The Thanet formation includes about 80 ft. of marls, clays, silts, glauconitic sandy silts and silty sands (Wentworth scale). Five divisions were originally recognized by the Geological Survey (W. Whitaker, 1872). These divisions, rather than those suggested by H. Burrows and R. Holland (1897) are followed here (Figure 2). In this work the following names are used for the members of the formation alphabetically designed by Whitaker:

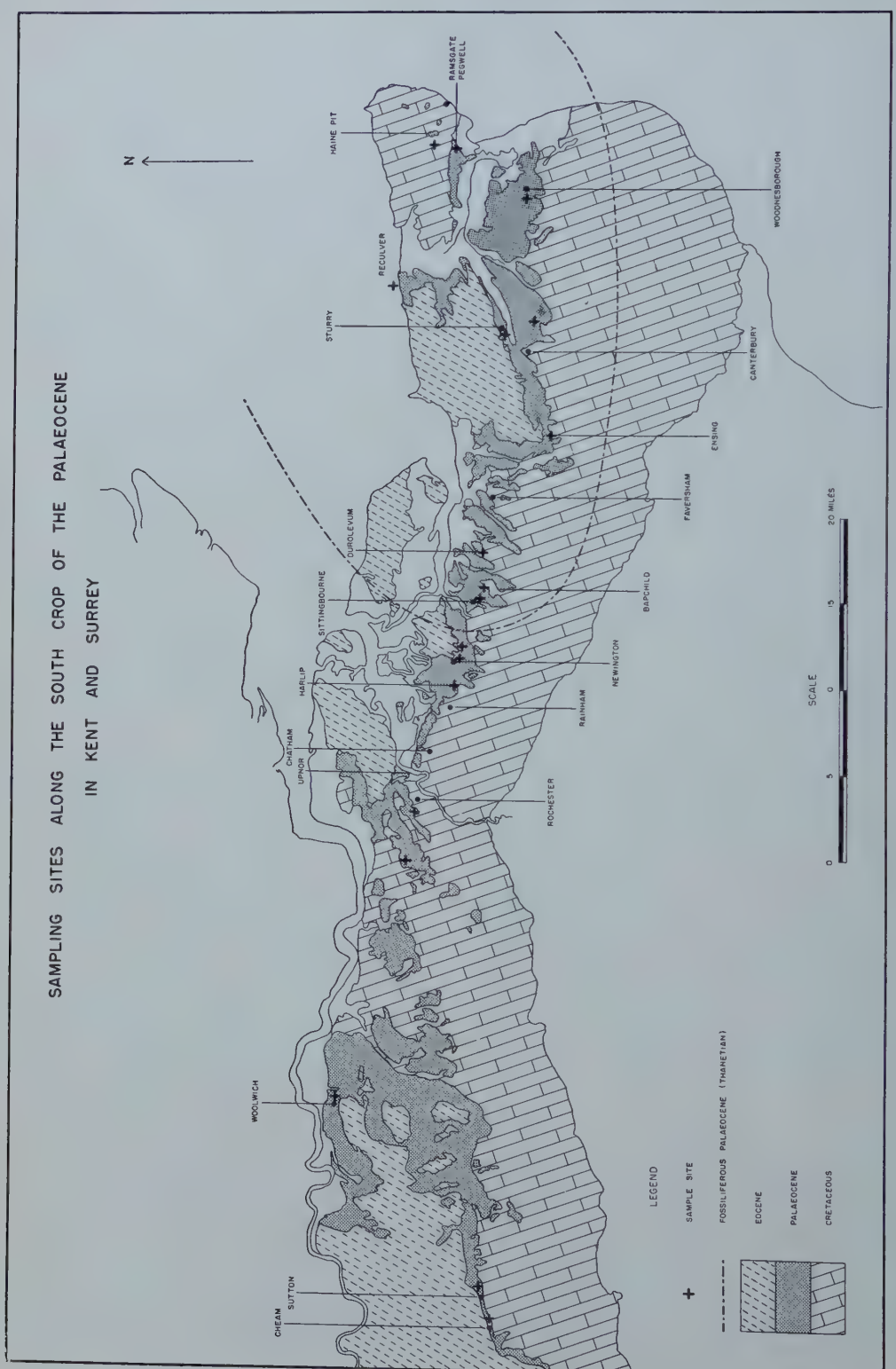
SAMPLING SITES ALONG THE SOUTH CROP OF THE PALAEOCENE
IN KENT AND SURREY
N
RAMSGATE
PEGWELL
HAINE PIT
RECULVER
STURRY
WOODNESBOROUGH
CANTERBURY
ENSING
FAVERSHAM
DUROLEVUM
SITTINGBOURNE
HARLIP
BAPCHILD
NEWINGTON
RAINHAM
CHATHAM
UPNOR
ROCHESTER
WOOLWICH
CHEAM
SUTTON
SCALE
0 5 0 15 20 MILES
LEGEND
SAMPLE SITE
FOSSILIFEROUS PALAEOCENE (THANETIAN)
EOCENE
PALAEOCENE
CRETACEOUS

FIGURE 1

e Reculver Silts
d Pegwell Marls
c Kentish Sands
b Stourmouth Clays
g Bullhead Flint Conglomerate

N.B. The Kentish Sands replace the Pegwell Marls and Reculver Silts west of Sittingbourne and therefore are not shown in figure 2. No Foraminifera were recovered from this member.

The species of Foraminifera described here were obtained from samples collected from the well-known sections at Pegwell Bay and Reculver Towers (Figure 2). Samples were collected at 50 cm. intervals, at the top and bottom of each bed and as continuous strips through the beds. Provenance of the particular specimens described is given in numbers referring to the stratigraphical columns illustrated (Figure 2).

The Thanet Beds are little disturbed and are not severely compacted, thus, where the members have escaped leaching, as in the cliff sections sampled, both the Pegwell Marls and the Reculver Silts yield well preserved microfaunas. There is no evidence of a mechanical relation between the faunas and the lithology. The fossiliferous mem-

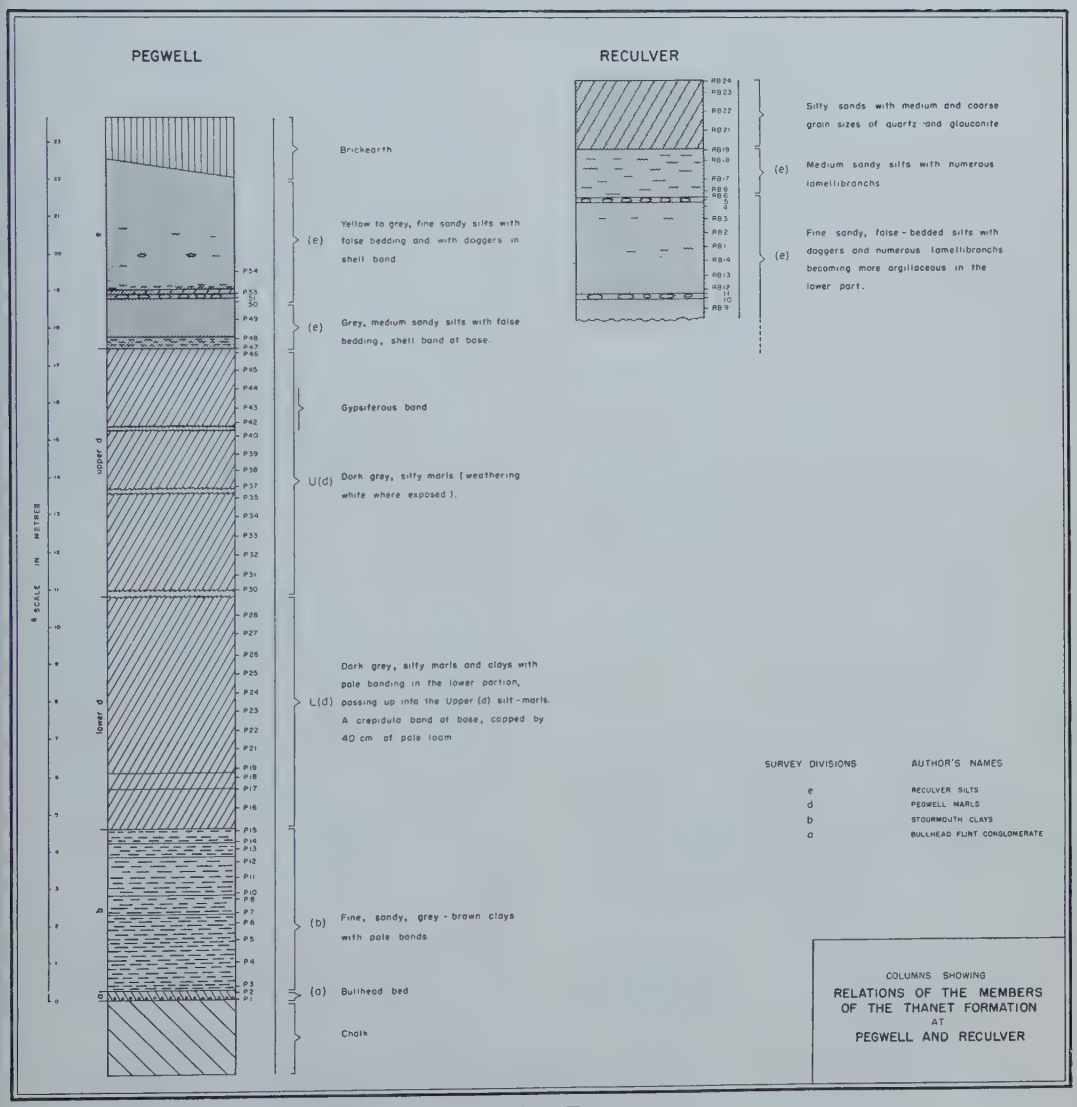

FIGURE 2

bers are poorly sorted silty marls and sandy silts with Foraminifera of much larger average size than the largest particles of the enclosing sediments. The Foraminifera are of all growth stages and therefore do not appear to have behaved as a coarse fraction of the sediments themselves.

Specimens derived from the Cretaceous occur rarely through the formation. One silicified specimen of *Globorotalites micheliniana* (d'Orbigny) was found at Pegwell. As silicified specimens of this species are abundant in the Bullhead Flint Conglomerate, together with *Globigerina cretacea* d'Orbigny, it is presumably derived. Specimens recovered of the genus *Gümbelina* were found to be silicified and presumably are derived also. The two species of *Gümbelina* recovered from the Reculver Silts are described below and the derived fauna of the Bullhead Bed will be described in a later paper.

Description and illustration.—In many of the species described a close relation is found between proloculus size and the number of chambers in each whorl. This is related to progressive changes in the ratio of chamber length to height with growth.

Care is taken to distinguish between the chambers visible on the periphery of helicoid or planispiral forms and the number actually present in the last completed whorl. The chambers in the first whorl are counted round to the one which overlaps onto the first chamber after the proloculus. Figures given of the number of chambers in the first whorl also include the proloculus. For instance, in the descriptions, a specimen with seven chambers in each of three whorls and an unfinished whorl of two chambers is recorded as possessing 7:7:7:2—, chambers. A knowledge of the total number of chambers developed and the number in each whorl is important in many species of *Asterigerina, Eponides* and *Epistominella* where the chambers tend to decrease in number of later whorls, this tendency being accelerated in megalospheric forms. Individual specimens show different numbers of chambers at the periphery although, in fact, the number of chambers in each whorl of comparable growth is often remarkably constant.

The figures of the species described in this paper were drawn by the author with the aid of a camera lucida and a micro-projector.

ACKNOWLEDGMENTS

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The author expresses his sincere thanks to Alan Wood, who directed the research, and to John Challinor for many helpful suggestions during the course of the study.

THE FORAMINIFERA

Family NONIONIDAE

Wood (1949) discovered that *Nonion* was a genus with granular walls and could be separated from the more complex radiate hyaline *Elphidium*. This led Bermudez (1952) to set up the subfamilies Nonioninae and Elphidiinae. It is interesting in this connection that all the species of *Nonionella* recovered from the Thanet Beds are granular, so also are three species placed under *Nonion*.

Two species resembling *Nonion* but radiate hyaline with multiple foramina are placed in a new genus, *Protelphidium*, genotype *Protelphidium hofkeri*, n.sp. This new genus can be regarded as a link between *Nonion* on the one hand and *Elphidiella* and *Elphidium* on the other.

This resolves the apparent conflict between the views of Wood (1949) and Brotzen (1948). Wood suggested that *Nonion* and *Elphidium* might be more widely separated from one another than had been thought. Brotzen, referring to his *Nonion* cf. *graniferum*, stated "species of the genus *Nonion* and of the genus *Elphidium* with a granulated *umbilical* area are closely related". *Protelphidium* covers these intermediate forms with granulated umbilical area, radiate hyaline walls and multiple foramina but without a canal system.

Smout (1955) groups *Elphidiella* in the Miscellaneidae and places *Elphidium* in a separate family, Elphidiidae, within his Rotaliidea. In his view the Nonionidae are quite unrelated to the Rotaliidea which he supposes to derive from the non-canaliculate Discorbidea. These views are not followed here and the occurence of species apparently intermediate between *Elphidiella* and *Nonion* is held to point to the origin of the Elphidiinae within the Nonioninae.

Genus **Nonionella** Cushman, 1926

Nonionella aff. **N. austinana** Cushman

Plate 16, figures 6, 6a

See 1933, *Nonionella austinana* Cushman, Contr. Cush. Lab., Foram. Res., vol. 9, pt. 3, p. 57, pl. 7, figs. 2a-c.

Description.—Test biconvex, ventral side involute, dorsal side evolute with all chambers visible; periphery broadly rounded; chambers 10 in number, 7:3-, in successive whorls, 7 visible ventrally, increasing in size rapidly; sutures flush, almost straight; ventral umbilicus partly covered by a small projection of the last chamber; aperture ventral beneath a slight lip; wall granular; pores minute on both sides.

Dimensions.—Diameter 0.3 mm.; maximum width 0.14 mm.

Horizon.—RB9, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42577.

Discussion.—Two specimens were obtained. The one figured shows a specimen very like *N. austinana* Cushman but with more chambers visible. The sutures appear to be more radial and flush, not slightly impressed. There is a possibility that these Thanet specimens are microspheric representations of the species. *N. ovata* Brotzen has five or six chambers visible ventrally and a marked umbilical flap on the ventral side.

Nonionella cretacea Cushman

Plate 16, figures 1-1i

1931. *Nonionella cretacea* Cushman, Tennessee Geol. Surv. Bull. 41, p. 42, pl. 7, figs. 2a-c.

1939, *Nonionella cretacea* Cushman, U. S. Geol. Surv. Prof. Paper 191, p. 28, pl. 7, fig. 5.

Distinguishing Features.—A compressed, almost biconvex *Nonionella* with up to ten chambers visible at the periphery, tending to become evolute (in what are probably megalospheric forms) with later chambers of variable length.

Description.—(Plate 16, figs. 1h, 1i). Test compressed, ventral side involute, dorsal side evolute; periphery entire; chambers 13, 7:6-, in successive whorls, 10 visible at the periphery, increasing rapidly in height; sutures almost radial, very slightly impressed; aperture ventral beneath a slight lip; wall granular; pores minute on both sides.

Dimensions.—Diameter 0.36 mm.; width 0.12 mm.; height of thirteenth chamber five times that of the seventh chamber.

Horizon.—RB1, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42578.

Alternation of Generations.—Proloculus diameters range about 0.02 mm.-0.025 mm. In one specimen recovered the diameter is rather less, 0.019 mm.; this rather more closely coiled form may represent the microspheric generation (Plate 16, figs. 1, 1a).

Variation.—The figures illustrate the chief variation amongst the forms recovered including chamber height, suture impression and lobation of outline.

Discussion.—The specimen described is very similar to those described by Cushman though the range of form is much greater in the Thanet population group than in American Upper Cretaceous forms, and specimens reach a greater size, up to 0.35 mm. in diameter rather than 0.25 mm., possibly justifying a varietal name.

It is interesting to note that the so-called *Nonion depressulum* (Walker and Jacob) was recovered from Reculver beach sands. One of the specimens figured here (Plate 16, fig. 1) is near in character to Walker and Jacob's type figure, so there is a possibility that the specimen collected by Walker and Boys was derived from Reculver cliffs. As an example of the various interpretations put upon Walker and Jacob's figure, Burrows and Holland, following H. B. Brady, placed specimens described by me as *Protelphidium hofkeri,* n.sp. under N. *depressulum.*

Range.—Upper Cretaceous (Taylor) Texas, (Velasco) Mexico.

Nonionella robusta Plummer var. **perdita** Haynes, n. var.

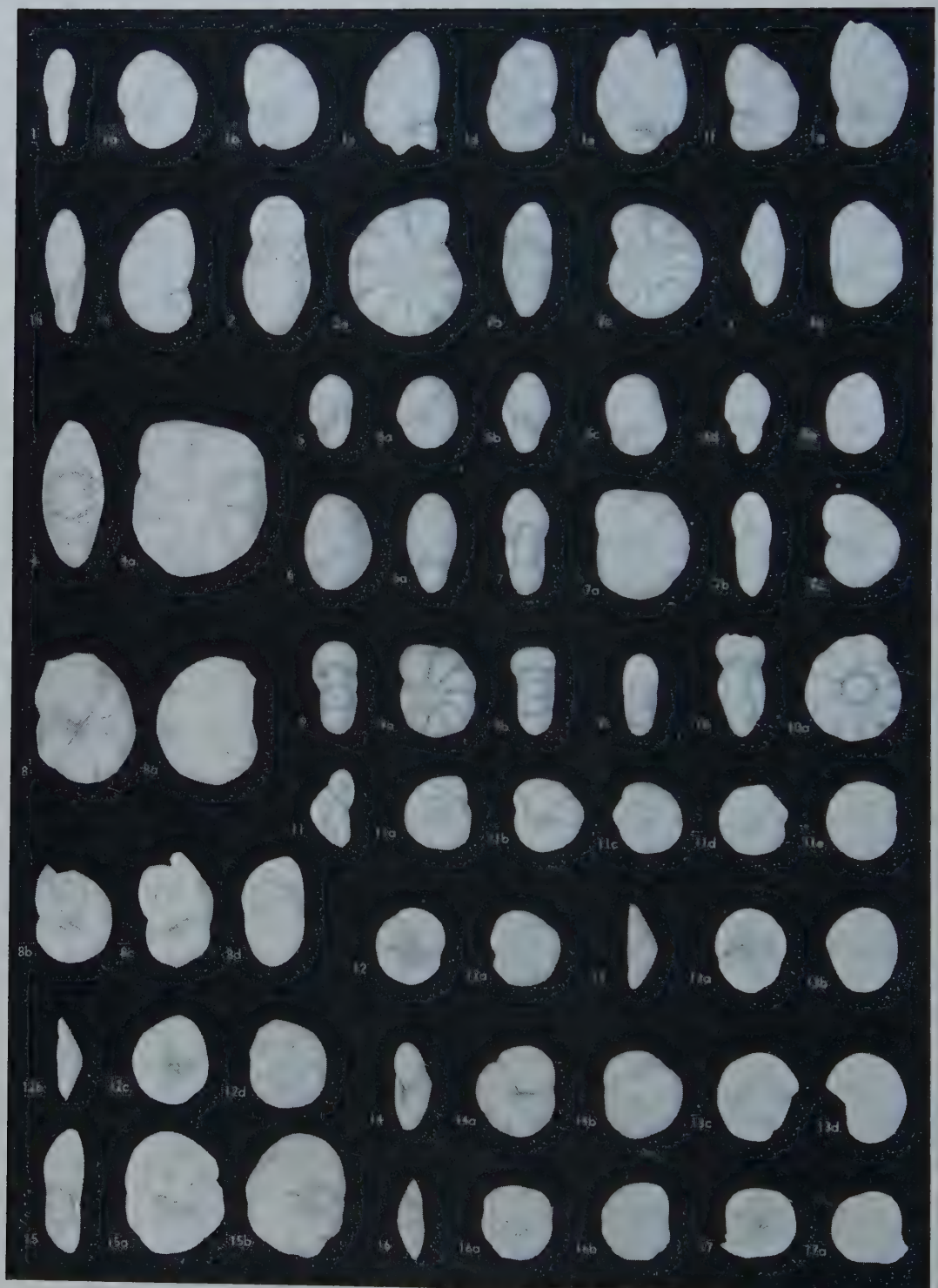
Plate 16, figures 5-5e; Plate 18, figure 5

Distinguishing Features.—A variety of *Nonionella robusta* with six chambers, rather than eight, visible ventrally.

Description.—(Plate 16, figs. 5, 5a). Test biconvex, involute, ventral side higher than evolute dorsal side; periphery broadly rounded, entire; apertural face of terminal chamber quadrangular; chambers 10, 6:4-, in successive whorls, 6 visible ventrally; sutures flush, backward curving; ventral umbilicus filled with the basal lobe of the last chamber; aperture ventral; wall granular; pores round and minute on both sides.

Dimensions.—Diameter 0.22 mm., width 0.13 mm.

Horizon.—P38, Pegwell Marls.



Haynes: British Paleocene Foraminifera

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42579. Additional specimens, P42580.

Discussion.—Proloculus diameters in the specimens recovered range about 0.025 mm. in diameter, the specimens may thus represent one generation only, possibly the megalospheric generation. *Nonionella robusta* Plummer is minute and apparently rather more elongate than the Thanet specimens with up to nine chambers visible on the periphery.

Nonionella sp.

Plate 16, figures 3, 3a

Description.—Test compressed, dorsal side evolute, ventral side involute; periphery sub-rounded, lobate; chambers 7, 6:1-. in successive whorls, 6 visible ventrally; sutures radial, impressed; ventral umbilicus filled with the basal lobe of the last chamber; aperture ventral, at the basal suture beneath a lip; wall granular; pores minute on both sides of the test.

Dimensions.—Diameter 0.3 mm.; width 0.10 mm.

Horizon.—RB1, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42581.

Genus **Nonion** Montfort, 1808

Nonion applinae Howe and Wallace

Plate 16, figures 7-7c; Plate 18, figure 4

1932. *Nonion applinae* Howe and Wallace, Louisiana Dept. Cons., Geol. Bull., no. 2, p. 51, pl. 9, figs. 4a, b.

1939. *Nonion applinae* Cushman, Geol. Surv. Prof. Paper 191, p. 8, pl. 2, fig. 7.

Distinguishing features.—A compressed *Nonion* with high oval chambers, up to nine in number, with almost radial sutures, only slightly, if at all, impressed. Secondary shell material tends to be restricted to the umbilicus. The foramina are central and oval in shape.

Description.—(Plate 16, figs. 7, 7a). Test biconvex, compressed; periphery sub-round; 8 chambers visible; sutures radial, slightly impressed; apertural face high, oval and convex, slight lip at base; aperture not visible but presumably at the basal suture beneath the lip; wall granular, thin and transparent; pores small, round and dense on both sides of the test; secondary shell material fills the shallow umbilici.

Dimensions.—Diameter 0.32 mm.; width 0.12 mm.

Horizon.—P51, Reculver Silts.

EXPLANATION OF PLATE 16

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42580.

Variation.—There appear to be two groups of specimens, those with 6½-7½ chambers visible and those with about 8½ visible. These may represent different generations. Some specimens show a more angular periphery.

Discussion.—The Thanet specimens appear to be identical with those of Howe and Wallace in all but size, being smaller, up to 0.35 mm. in diameter rather than up to 0.45 mm.

Range.—Upper Eocene (Jackson) Louisiana, Texas, Vera Cruz.

Nonion laeve (d'Orbigny)

Plate 16, figures 10, 10a

1826, *Nonionina laeve* d'Orbigny, Ann. Sci. Nat., vol. 7, p. 294, no. 11, modèles 46.

1850, *Nonionina laeve* d'Orbigny, Prodome de Paléont. Strat., Paris, vol. 2, p. 406, no. 1304.

1882. *Nonionina laeve* Terquem, Mém. Soc. Géol. France, ser. 3, tome 2, no. 3, p. 129.

1939, *Nonion laeve* Cushman, U. S. Geol. Surv. Prof. Paper 191, p. 3, pl. 1, figs. 6, 7.

Distinguishing Features.—A compressed *Nonion* with 9-11 chambers visible and subangular periphery becoming rounded in later chambers. In adult specimens bosses replace the secondary shell material filling the umbilici.

Description.—Test biconvex, compressed (terminal chamber broken); periphery subangular, becoming rounded and semilobate in the last few chambers; 10 chambers visible; sutures backward curving, deeply impressed towards the umbilicus; apertural face trigonal and convex with a slight lip at the base; aperture not visible but presumably at the basal suture beneath the lip; wall granular; pores minute on both sides; large bosses and a small amount of secondary shell material fill the umbilici.

Dimensions.—Diameter 0.3 mm., width approximately 0.12 mm.

Horizon.—RB1, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42583.

Discussion.—Only a few specimens were recovered of this species. These are smaller than the types from the upper Eocene having 9-10, rather than 10-12 chambers, but otherwise appear to be identical.

Range.—Upper and middle Eocene, Paris Basin.

Nonion reculverensis Haynes, n. sp.

Plate 16, figures 4, 4a

Distinguishing features.—A *Nonion* with eight chambers in each whorl, entire, subangular periphery and limbate sutures fusing in central bosses.

Description.—Test biconvex, compressed; periphery subangular, entire; 8 chambers visible; sutures limbate, backward curving, impressed between the last two chambers; apertural face trigonal and convex; aperture median at the basal suture; wall granular; pores minute; bosses fill the umbilici.

Dimensions.—Diameter 0.22 mm.; maximum width 0.09 mm.

Horizon.—RB2, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42584, additional specimens P42585.

Discussion.—The specimens recovered of this small species appear to be very stable in form and may represent one generation only.

Genus **Protelphidium,** Haynes, n. gen.

Genotype *Protelphidium hofkeri* Haynes, n. sp.

Generic characters.—The genus *Protelphidium* includes members of the Nonionidae which are radiate hyaline, involute, with or without multiple apertures but without sutural pores or retral processes. The genus differs from *Nonion* Montfort in being radiate hyaline not granular and in the development of multiple foramina. It differs from *Elphidium* Montfort in its lack of retral processes and from *Elphidiella* Cushman, in its lack of sutural pores.

Protelphidium hofkeri Haynes, n. sp.

Plate 16, figures 9-9c; Plate 18, figure 3

? 1897, *Nonionina depressula* Burrows and Holland (not Walker and Jacob), Proc. Geol. Assoc., vol. 15, p. 49, listed only.

Distinguishing features.—A *Protelphidium* with 8 chambers in the second whorl of megalospheric specimens and 9 to 10 chambers in the second whorl of microspheric specimens. The chambers are depressed with impressed, backward curving sutures. Secondary shell material fills the umbilicus and extends some distance along the sutures.

Description.—(Plate 16, figs. 9, 9a). Test biconvex, chambers depressed; periphery broadly rounded, semi-lobate; 8 chambers visible; sutures backward curving, deeply impressed; aperture

not visible, presumably at the basal suture; wall radiate hyaline; pores minute, round and densely distributed on both sides of the test; secondary shell material fills the shallow umbilici on both sides.

Dimensions.—Diameter 0.27 mm.; width 0.12 mm.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42586.

Horizon.—RB19, Reculver Silts.

Alternation of Generations.—Sections, more than two dozen, show that two groups of proloculus size exist with diameters about 0.025 mm. and about 0.035 mm. to 0.045 mm. In the first group chambers total up to 25, 7:9 or 10:-4. in successive whorls, 9 visible at the periphery. In the second group chambers total up to 15, 7:8:-, in successive whorls, 8 visible at the periphery. At least two generations may thus be represented.

Variation.—The development of foramina is variable. There is sometimes a single low foramen of different lengths in different specimens. In other specimens there may be up to three or more. No connection was observed between these changes and growth. Some specimens, from which the secondary shell material has been removed, show openings at the umbilical ends of the chambers. The possibility that these openings may be secondary apertures is suggested by the invariable lack of a visible aperture at the periphery.

Discussion.—Burrows and Holland referred this form (listed only) to *Nonion depressulum* (Walker and Jacob) following Brady's figure (see discussion of *Nonionella cretacea* Cushman). It is possible that Brady's specimen, from shore sands at La Rochelle should be referred to *Nonion akitaense* Asano, a Pliocene species with high chambers and lobate outline. *Nonion tallahatensis* Bandy is near this form but possesses multiple apertures. It would be interesting to know the wall structure of these species. According to Wood, 1949, *N. depressula,* in Brady's sense, was radiate.

Range.—Upper and middle Eocene, Paris Basin; ? Paleocene, Sweden.

Derivation of name.—In honour of Jan Hofker.

Protelphidium sublaeve (Ten Dam)

Plate 16, figures 2-2c

1944, *Nonion sublaeve* Ten Dam, Med. Geol. Sticht. Ser. C-V, no. 3, p. 109, pl. 3, fig. 8.

Distinguishing features.—A *Protelphidium* with up to eleven slightly depressed chambers. The outline is entire, except in the last part where it becomes slightly lobate, and the umbilici are filled with secondary shell material.

Description.—(Plate 16, figs. 2, 2a). Test biconvex; periphery broadly rounded, entire; 10 chambers visible at the periphery; sutures backward curving, impressed, particularly towards the umbilicus; apertural face depressed, oval in apertural view, flattened in side view; aperture not clearly visible but apparently at the basal suture; wall radiate; pores minute, densely distributed on both sides; umbilici filled with secondary shell material.

Dimensions.—Diameter 0.43 mm.; width 0.21 mm.

Horizon.—RB8, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42587.

Discussion.—Ten Dam's figure is poor and apparently shows a more compressed form than the otherwise similar Thanet forms. The species differs from *P. hofkeri,* n.sp. in its larger size, entire periphery, greater number of chambers and in its raised rather than depressed sides.

Range.—Paleocene, Netherlands.

Family CHILOSTOMELLIDAE

Genus **Pullenia** Parker and Jones, 1862

Pullenia platti Haynes, n. sp.

Plate 17, figures 18-18b

Distinguishing features.—A globose *Pullenia* with six chambers in each whorl and limbate sutures. There is a tendency for the test to uncoil slightly and become evolute on one side or both.

Description.—(Plate 17, figs. 18-18b). Test semi-compressed, becoming evolute, more on one side than the other; periphery broadly rounded, entire; 6 chambers visible at the periphery; sutures backward curving, limbate; apertural face depressed in apertural view, flattened in side view; aperture low at the basal suture; wall granular; pores not observed; umbilici filled with clear glassy material.

Dimensions.—Diameter 0.54 mm.; maximum width 0.24 mm.

Horizon.—P16, Pegwell Marls.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42575. Additional specimens P42576.

Discussion.—A number of specimens of this peculiar species were recovered from the Crepidula Band. It is quite distinct from the other species of *Pullenia* found and apparently from any species described.

Derivation of name.—This species is named in honour of John I. Platt.

Family EPISTOMINIDAE

Glaessner (1937 and 1945) has interpreted the Ceratobuliminidae widely and taken it to include *Epistomina* as well as *Ceratobulimina*. Brotzen (1942 and 1948) on the other hand, has separated the Epistominidae from the Ceratobuliminidae on the grounds of their marginal rather than umbilical apertures. In addition he pointed out that the partition joins the dorsal wall in *Epistomina* whereas it joins the ventral wall in *Ceratobulimina* (see Plate 2, fig. 8d). He further supposed that the apertural parts of *Alabamina* resembled those of *Epistomina*, much reduced, and that this genus together with *Epistominella*, *Parrella* and *Siphonina* could be included in the *Epistominidae*. This view of the family is taken by Sigal, 1952. Cushman (1948) also groups *Siphonina* with *Epistomina* in his Siphonininae which is, however, grouped in the Rotaliidae.

Brotzen's classification is followed here, except that *Siphonina* is placed in the Discorbidae, but considerable doubt remains. *Epistominella vitrea* Parker is shown by the present study to be radiate hyaline with minute pores and is thus in these characters near to *Ceratobulimina* and *Epistomina*. The interval tooth plate is, however, very simple resembling that in *Cassidulina*.

Hofker (1951) supposed that *Epistominella* derived from the Ceratobuliminidae and grouped it with *Eponides*, in his Eponidae, on the grounds that *Eponides* represents an advanced form in which the tongue is reduced. As the foramina do not reach the base of each septum in *Eponides* this is held to suggest that the aperture is primary (a protoforamen) similar to the apertures in his sub-order Biforaminata-Protoforaminata. Wood (1949) has shown that *Eponides* is radiate and minutely perforate but until intermediate forms are discovered linking *Epistominella* with *Eponides* more definitely it would seem best to classify *Epistominella* provisionally with the Epistominidae.

The position of *Alabamina* is also uncertain. Examination of the Thanet species *A. obtusa* (Burrows and Holland) and of the Wilcox species, *A. wilcoxensis* Toulmin, during the course of the present study proves *Alabamina* to be granular. Wood (1949) has shown that *Gyroidina* is also a granular genus. This may support Hofker's view that *Alabamina* and *Gyroidina* form a family separate from the Epistominidae and characterised by reduction of the supposed marginal aperture (marginal protoforamen) and the development of a secondary aperture at the basal suture (deuteroforamen). Apart from wall structure and the fact that the foramina are at the basal suture in both genera (held by Hofker to indicate derivation from members of the Deuteroforaminata) *Alabamina* would appear to be nearer the Epistominidae in general structure than it is near *Gyroidina* and its allies.

Genus **Epistominella** Husezima and Maruhasi, 1944

Epistominella vitrea Parker

Plate 16, figures 11-11e

1953, *Epistominella vitrea* Parker, Contr. Cush. Found. Foram. Res., Spec. Pub., no. 2, p. 9, pl. 4, figs. 34-36, 40-41..

Distinguishing features.—An *Epistominella* with six or seven chambers in the third whorls of megalospheric specimens, eight in microspheric specimens. The dorsal side is high and the ventral side flattened with a shallow umbilicus. On the ventral side the sutures are radial and flush.

Description.—(Plate 16, figs. 11-11b). Specimen megalospheric; test highest on the evolute dorsal side, involute ventral side flattened with a shallow umbilicus; periphery entire. sub-rounded; chambers 23 in number, 7:7:7:2-, in successive whorls, 7 visible ventrally; sutures flush, radial on the ventral side, backward curving on the dorsal side; aperture loop-shaped, in the median plane within a deep fold of the apertural face, dorsal edge free and curving out in a slight lip, ventral edge infolded and connecting internally with a tooth plate which apparently joins the base of the chamber and runs across to the opposite, dorsal edge of the previous foramin; the edges of the aperture fuse together well above the basal septal suture; wall radiate hyaline; pores minute on both sides.

Dimensions.—Diameter 0.23 mm.; width 0.13 mm.; proloculus about 0.018 mm. in diameter.

Horizon.—RB12, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist. Cat. no. P42589.

Alternation of generations.—There appear to be at least three groups of proloculus size, ranging about 0.009 mm., about 0.018 mm., and about 0.025 mm. These groups which may represent the microspheric generation and two successive megalospheric generations tend to show the following

chamber arrangement respectively:

7:9:8:1-, up to about 25 in all.
7:7:7:2-, up to about 23 in all.
7:6:6, up to about 19 in all.

Discussion.—Thanet specimens with the largest megalospheres resemble Parker's holotype with six chambers in the third whorl. Parker may have described megalospheric forms only or it is possible that the recent population has fewer chambers in each whorl in both generations and is thus a genetically distinct variety.

Among allied species *E. naraensis* (Kuwano) is most closely related but differs in that it is biconvex, without the pronounced ventral flattening and shallow umbilicus of *E. vitrea*. *E. oweyi* Bhatia is probably identical with *E. vitrea*.

Range.—Recent, Mississippi Delta; possibly also Oligocene, Hampshire.

Genus **Alabamina** Toulmin, 1941

Alabamina obtusa (Burrows and Holland)

Plate 17, figures 3-31

1897, *Pulvinulina exigua* (Brady) var. *obtusa*. Burrows and Holland, Proc. Geol. Assoc., vol. 15, p. 49, pl. 2, fig. 25.

1926, *Pulvinulina exigua* var. *obtusa* Plummer, Texas Univ. Bull., no. 2644, p. 151, pl. 1x1, figs. 2a-c.

1948, *Alabamina midwayensis* Brotzen, Sver. Geol. Undersok., Ars. 42, no. 493, p. 99, pl. 16, figs. 1,2.

Distinguishing features.—A sub-globose *Alabamina* with rounded periphery and five chambers in each whorl. The test is biconvex or with the ventral side the highest.

Description—(Plate 17, figs. 3b-3d). Test subglobular, biconvex, dorsal side evolute, ventral side involute; periphery entire, sub-rounded; chambers 16 in number, 5:5:5:1-, in successive whorls; sutures radial and slightly impressed on the ventral side, swept back on the dorsal side and almost straight by the second whorl; apertural face well marked, infolded into a deep "infundibulum" parallel to the periphery; aperture a narrow opening along the central portion of the basal suture; wall granular; pores not discerned.

Dimensions.—Diameter 0.37 mm.; width 0.20 mm.; diameter of proloculus about 0.03 mm.; height of chamber at close of the second whorl about twice that at close of the first whorl.

Horizon.—P22, Pegwell Marls.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42590, additional specimens P42591.

Alternation of generations.—Variation in proloculus size was not observed.

Variation.—Specimens were found to vary chiefly in the height of the dorsal side, showing all graduations from biconvexity to dorsal flattening. Certain specimens possess more inflated chambers and lobate outlines and one was found to be pentagonal in outline (Plate 17, fig. 3k and fig. 31).

Discussion.—*Alabamina obtusa* differs from *A.wilcoxensis* Toulmin in its smaller size and rounded periphery. Plummer referred certain Midway specimens to *A. obtusa* because of their obtuse peripheries stating that some were almost globular. It seems likely that the typical upper Midway *Alabamina* is *A. obtusa*, perhaps giving way in the Wilcox to *A. wilcoxensis*.

Brotzen (1948) has included Plummer's specimens in his *Alabamina midwayensis*, set up to cover forms intermediate between *A. wilcoxensis* and *A. obtusa*. He states, "all variants of this Midway species are well distinguished from the typical *Alabamina obtusa* by their low septal face and the flat test". Previously, however, in the same work, he had stated, "these species are very similar and only their variants and extreme forms distinguish them". If the later statement is nearer the truth then *A. midwayensis* would appear to have no more than varietal status.

Brotzen based his views on topotypes of the Thanet species which were, "very obtuse and globular; their umbilical side was much higher than the spiral side and consequently the septal wall was also higher than broad". Presumably by "higher than broad" Brotzen means more upright in relation to the median plane as the apertural face is never more than half as wide as high in any hitherto described *Alabamina*. All three topotypes figured by Brotzen are higher ventrally in relation to their diameter than is usual in the Thanet specimens. One specimen appears to be abnormal as the last chamber arches over the periphery onto the dorsal side. Only one Thanet specimen I have seen (Plate 2, fig. 3j) shows the extreme ventral height of the other two topotypes of Brotzen. It is therefore considered unjustifiable to give specific distinction to the specimens from the Texas Midway. Swedish forms with more acute periphery than those from Thanet should probably be included in *A. wilcoxensis*. *A. obtusa* Colom from the Lower Oligocene of Navarra is referred to as carinate so it probably also related to *A. wilcoxensis*. *Pseudoparrella obtusa* Leroy definitely appears to be *A. wilcoxensis*.

Range.—Paleocene, Texas, Sweden.

Family CERATOBULIMINIDAE

Genus **Ceratobulimina** Toula, 1915

Ceratobulimina tuberculata Brotzen

Plate 16, figures 8-8d; Plate 18, figure 8

1948, *Ceratobulimina tuberculata* Brozten, Sver. Geol. Undersok., Ars. 42, ser. C, no. 493, p. 124, pl. 19, figs. 2, 3.

Distinguishing features.—A sub-globular *Ceratobulimina* with six chambers in the second whorls of megalospheric forms and a minutely tuberculate ventral umbilicus.

Description.—(Plate 16, figs. 8, 8a). Test subglobular, biconvex, dorsal side evolute, ventral side involute, deeply umbilicate; periphery broadly rounded, semi-lobate; chambers 10 in number, 5:5-, in successive whorls; ventral sutures radial, deeply impressed towards the umbilicus, dorsal sutures limbate, backward curving; last chamber broken, an oval foramen visible above the broken edges of the internal plate; wall radiate hyaline; pores very small, densely distributed; tubercles cover the umbilicus and the septal face below the foramen.

Dimensions.—Diameter 0.38 mm.; proloculus diameter about 0.027 mm.; height of tenth chamber two and a half times that of the fifth chamber.

Horizon.—P47, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42588.

Alternation of generations.—The specimens recovered show proloculi with diameters ranging about 0.025-0.03 mm.; and are possibly representatives of one generation only.

Discussion.—The apertural face is usually broken off in the specimens recovered. In Plate 16, fig. 8b, a specimen is illustrated in which the last chamber is preserved showing the umbilical aperture beneath a serrate ventral flap and the internal plate below the foramen. Two breached specimens (figs. 8c and 8d) show the character of this plate which is joined to the ventral side of the chamber. On the dorsal side there is a crescent-shaped orifice which provides passage to the umbilical aperture. The free edge of the plate is curved over.

Range.—Paleocene, Sweden.

Family DISCORBIDAE

Glaessner (1945) grouped three subfamilies, the Discorbinae, the Siphonininae and the Anomalininae in the Discorbidae. This family is generally equivalent to the Rotaliidae of Brotzen, Cushman and Bermudez and the Discorbidae of Sigal.

The classification of Brotzen (1942, 1948) differs from that of Glaessner in that *Valvulineria* and *Gyroidina* are grouped in a separate subfamily apart from *Discorbis*. In addition *Siphonina, Alabamina* and *Epistominella* are placed in the Epistominidae.

Cushman's Rotaliidae (1948) differs from Glaessner's Discorbidae in that *Anomalina* and *Cibicides* are placed in a separate family, Anomalinidae. Cushman also groups *Epistomina* with *Siphonina* and places *Epistominella* and *Alabamina* with the Cassidulinidae.

Sigal (1952) separates both the *Anomalina* group and *Siphonina* and *Alabamina* from the Discorbidae.

Hofker (1951) adopted quite a different scheme from that followed by previous authors. *Cibicides* and *Eponides* are included in his suborder Biforaminata together with *Siphonina* and *Alabamina,* whereas *Discorbis* and *Rosalina* (his *Discopulvinulina*) are included in the suborder Deuteroforaminata together with *Valvulineria, Asterigerina* and *Amphistegina.*

A conservative view is here taken of Hofker's classification. A grave objection is that wall structure is disregarded. Further, undue weight appears to be attached to minor features, as in the case of *Gyroidina* which is placed with *Alabamina* largely on the grounds that its foramina are at the basal suture. As yet there would appear to be no real evidence for placing the *Valvulineria* group in a different suborder from *Eponides, Cibicides* and *Gyroidina.*

This is not to say that the relations of the Rotalids and their allies are simple. The wide variation in wall structure of these forms seems to indicate that their phylogeny is at least as complicated as suggested by Hofker.

In this work the classification of Glaessner has been followed, modified in certain particulars. *Alabamina* and *Epistominella* are excluded from the Discorbinae and *Charltonina* is included in the Siphonininae.

Subfamily DISCORBINAE

Glaessner (1945) and Cushman (1948) have regarded *Discorbis* Lamarck as a prior synonym of *Rosalina* d'Orbigny. Brotzen, however, has recognised *Rosalina* while Bermudez has recognised both

genera. Hofker has set up *Discopulvinulina* but as he describes *Rosalina globularis* d'Orbigny as being typical of the genus the name should be dropped.

The Thanet specimens placed under *Rosalina* are granular, those specimens placed under *Discorbis* radiate in wall structure. Wood (1949) has shown the genotypes of both genera to be radiate. It is thus possible that the species placed here under *Rosalina* are actually generically or subgenerically distinct, as is suggested by the unusual boss and secondary shell material within the ventral umbilicus of *Rosalina koeneni* Brotzen. *R. mimiconcinna,* n.sp. is likewise unusual in the fewness of chambers visible on the ventral side. On the other hand the possession of a granular or hyaline wall may perhaps be of specific distinction only. It is interesting that whereas radiate wall structure is well established in advanced groups such as the Globigerinidae, Nummulitidae and Miogypsinidae, many genera within the Anomalininae and Discorbinae are granular. If, in fact, *Rosalina* and *Discorbis* represent the primitive root stock from which these groups are derived they might possibly be expected to show variation of wall structure at a specific level. Conversely, the possibility must be considered that the present classification cuts sharply across genetic lines. It ignores the difference between radiate or granular species and genera and may well present as confused a picture as would be presented by a classification that failed to distinguish between calcareous hyaline genera and their porcellaneous homeomorphs.

Gyroidina is grouped with *Discorbis* by Glaessner, Cushman and Sigal, it is grouped with the Valvulinerinae by Brotzen and in a separate family, the Alabamidae, by Hofker. The genus is granular and in this respect is nearer *Alabamina* than it is to the radiate *Valvulineria.*

Gyroidina danvillensis Howe and Wallace has been placed under *Valvulineria* by Bandy. It is interesting in this connection that Thanet specimens apparently identical with Howe and Wallace's species are granular. The aperture in this species is intermediate between these two genera, being long and low at the basal suture and running from periphery to umbilicus beneath a lip. The umbilicus is not deep as in the typical *Gyroidina* but there is no distinct flap and umbilical projection as in *Valvulinera.* The character of this species would seem to support the idea that *Gyroidina* and *Valvulineria* are closely related rather than members of separate suborders as postulated by Hofker.

Genus **Rosalina** d'Orbigny, 1826

Rosalina koeneni Brotzen

Plate 16, figures 12-12d; Plate 18, figure 6

1948, *Rosalina koeneni* Brotzen, Sver. Geol. Undersok., Ars. 42, ser. C, no. 493, p. 73, pl. 9, fig. 11.

Distinguishing features.—A carinate *Rosalina* with six chambers in the second whorls of megalospheric specimens. The sutures are depressed at the umbilicus on the ventral side and are generally filled with secondary shell material forming a star-shaped figure with a boss at the centre.

Description.—(Plate 16, figs. 12-12a). Test concavo-convex, dorsal side convex, evolute, ventral side involute, periphery carinate; chambers 13; 6:6:1-, in successive whorls; dorsal sutures swept back; ventral sutures swept back, depressed towards the umbilicus and filled with secondary shell material; aperture umbilical beneath a projecting lobe of the last chamber; wall granular; pores small, round, equally distributed on both sides of the test; ventral umbilicus with a small boss.

Dimensions.—Diameter 0.22 mm.; proloculus about 0.018 mm. in diameter.

Horizon.—RB11, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42594.

Alternation of generations.—One specimen was recovered with a small initial coil. This appears to indicate that the specimen described represents the megalospheric generation.

Variation.—Development of secondary shell material within the ventral umbilicus is very variable.

Range.—Paleocene (Ystad) Sweden.

Rosalina mimiconcinna Haynes, n. sp.

Plate 16, figures 13-13d

Distinguishing features.—A *Rosalina* with rounded periphery and three chambers in the third whorls of microscopic specimens. In megalospheric specimens the number of chambers is reduced to three by the second whorl.

Description.—(Plate 16, figs. 13-13b). Test concavo-convex, dorsal side convex, evolute, ventral side involute, periphery sub-rounded; chambers about 9 in number, not all visible on the dorsal side, 3 visible on the ventral side; aperture umbilical beneath a projecting lobe of the last cham-

ber; wall granular; pores minute.

Dimensions.—Diameter 0.24 mm.; proloculus about 0.02 mm. in diameter.

Horizon.—P51, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42595. Additional specimens P42596.

Alternation of generations.—There appear to be at least two proloculus size groups. Figs. 13c, 13d illustrate what may be a microspheric specimen with proloculus about 0.013 mm. in diameter.

Discussion.—This species resembles *Discorbis concinna* Brady from Tahiti and the Admiralty Isles (referred recently to *Tretomphalus*) but is granular not radiate.

Rosalina cf. **R. ystadiensis** Brotzen

Plate 16, figures 17, 17a

See 1948, *Rosalina ystadiensis* Brotzen, Sver. Geol. Undersok., Ars. 42, ser. C, no. 493, p. 72, pl. 9, fig. 9.

Description.—Test concavo-convex, dorsal side convex, evolute, ventral side involute; periphery carinate; chambers 16, 6:7:3-, in successive whorls; sutures swept back, flush; last chamber broken but the position of the foramen of the previous chamber indicates that the aperture was at the basal suture; pores minute on both sides; ornament of scattered granules on the ventral side.

Dimensions.—Diameter 0.24 mm.; proloculus about 0.008 mm. in diameter.

Horizon.—RB11, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42597.

Discussion—One specimen was recovered that appears to be closely allied to Brotzen's species from the Swedish Paleocene, differing in the lack of radial marks on the periphery and in the larger area of tubercles on the ventral side.

Genus **Discorbis** Lamarck, 1804

Discorbis cf. **D. subaraucana** Cushman

Plate 16, figures 14-14b

See 1922, *Discorbis subaraucana* Cushman, Carnegie Inst. Wash., Pub. 311, p. 41, pl. 7, figs. 1,2.

1935, *Discorbis subaraucana* Cushman, U.S. Geol. Surv. Prof. Paper 181. p. 43, pl. 18, figs. 1a-c.

Description.—Test biconvex, ventral side involute, dorsal side evolute; periphery sub-rounded; chambers 15, 6:7:2-, in successive whorls, 5½ visible on the ventral side; sutures swept back, slightly impressed on the ventral side; aperture umbilical beneath a projecting lobe of the last chamber; wall radiate; pores minute and equally distributed on both sides.

Dimensions.—Diameter 0.27 mm.; proloculus about 0.02 mm. in diameter.

Horizon.—RB1, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42598.

Discussion.—The specimen recovered resembles Cushman's holotype in all but the shape of the later chambers, the last two being much lower and more scimitar-shaped on the dorsal side.

Discorbis (Rosalina) aff. **D. (R.) midwayensis** Cushman

Plate 16, figures 15-15b

See 1944, *Discorbis midwayensis* Cushman, Contr. Cush. Lab., Foram. Res. vol. 16, p. 70, pl. 12, fig. 6

Description.—Test concavo-convex, dorsal side convex, evolute, ventral side involute; periphery sub-acute; chambers 22, 7:10:4-, in successive whorls, 7 visible ventrally; sutures swept back, impressed between the last two chambers; aperture umbilical beneath a projecting flap of the last chamber; wall radiate hyaline; pores minute and densely distributed on both sides.

Dimensions.—Diameter 0.37 mm.; width 0.07 mm.

Horizon.—RB2, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42599.

Discussion.—Only a few specimens of this form were recovered. It is possibly a smooth variety of the papillate *D. midwayensis* from the Alabama Paleocene.

Discorbis sp.

Plate 16, figures 16-16b

Description.—Test biconvex, dorsal side evolute, ventral side involute; periphery keeled; chambers 15, 6:7:2-, in successive whorls, 6 visible ventrally; sutures swept back, impressed ventrally; last chamber broken exposing the foramen at the basal suture of the previous chamber; pores minute; the ends of the chambers project into the umbilicus on the ventral side and are deeply grooved.

Dimensions.—Diameter 0.25 mm.; proloculus 0.017 mm. in diameter.

Horizon.—RB3, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42606.

Genus **Gyroidina** d'Orbigny

Gyroidina? danvillensis Howe and Wallace

Plate 17, figures 2-2b

1932, *Gyroidina danvillensis* Howe and Wallace, Louisiana Dept. Cons. Geol. Bull., no. 2, p. 69, pl. 13, fig. 3.

Distinguishing features—A sub-globose *Gyroidina* with six to seven chambers in the second whorls of what appear to be megalospheric forms, high ventral side and rounded periphery.

Description.—Test sub-globose, ventral side involute, high, with shallow umbilicus, dorsal side evolute, low; periphery broadly rounded, entire; chambers 13, 7:6-, in successive whorls, 6 visible ventrally; sutures swept back, flush; apertural face quadrangular; aperture long and low extending the length of the basal suture beneath a lip; wall granular; pores minute.

Dimensions.—Diameter 0.3 mm.; width 0.15 mm.; proloculus 0.025 mm. in diameter.

Horizon.—P42, Upper Pegwell Marls.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42601.

Discussion.—Specimens referable to this species occur at the gypsiferous horizon at the top of the Pegwell Marls at Pegwell. Elsewhere in the Thanet Beds the species is replaced by the variety *G. danvillensis* var. *gyroidinoides.*

Range.—Upper Eocene (Jackson) Louisana.

Gyroidina? danvillensis var. **gyroidinoides** (Bandy)

Plate 17, figures 1-1b.; Plate 18, figure 9

1949, *Valvulineria danvillensis* var. *gyroidinoides* Bandy, Bull. Amer. Pal., vol. 32, p. 82.

Distinguishing features.—A variety of *G. danvillensis* with more chambers in each whorl, up to eight or nine in the second whorls of what may be megalospheric forms.

Description.—Test sub-globular, ventral side involute, high, with shallow umbilicus, dorsal side evolute, low; periphery broadly rounded; chambers 22, increasing in size slowly, 7:7:8, in successive whorls, 8 visible ventrally; sutures backward curving, thick on the dorsal side, slightly impressed ventrally; apertural face quadrangular; aperture long and narrow, extending from the periphery to the umbilicus along the basal suture beneath a lip; wall granular; pores small, round and densely distributed on both sides.

Dimensions.—Diameter 0.38 mm.; width 0.25 mm.; proloculus diameter about 0.025 mm.; height of chambers increasing to 0.03 mm. at close of the first whorl compared to about 0.06 mm. in *G. danvillensis.*

Horizon.—P20, Pegwell Marls.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42601.

Discussion.—No evidence was found to support the idea that this variety is a particular generation of *G. danvillensis*, the name, therefore, appears to have genetic justification. The Thanet specimens are very near to Bandy's type figures which, however, show a specimen with nine chambers at the periphery and are thus possibly further removed from the typical *G. danvillensis* than the Paleocene forms. Furthermore, Bandy's specimens are described as possessing raised sutures between the initial chambers on the ventral side.

Range.—Middle Eocene, Alabama.

Genus **Gyroidinoides** Brotzen, 1942

Gyroidinoides voluptus Haynes, n. sp.

Plate 17, figures 4-4f; Plate 18, figure 1.

Distinguishing features.—A globose *Gyroidinoides* with impressed sutures and six chambers in each whorl after the initial whorl.

Description.—(Plate 17, figs. 4-4b) Test biconvex, ventral side involute, umbilicus deep, dorsal side evolute; periphery broadly rounded; chambers 16, 7:6:3—, in successive whorls, 6 visible ventrally, sutures impressed, radial; apertural face depressed; aperture long and low beneath a lip extending from near the periphery to the umbilicus; wall granular, milky white; pores round and scattered with smaller pores between them.

Dimensions.—Diameter 0.44 mm.; width 0.25 mm.; proloculus 0.03 mm. in diameter

Horizon.—P22, Pegwell Marls.

Depository.—Brit. Mus. Nat. Hist., Cat no. P42603. Additional specimens P42604.

Alternation of generations.—Specimens were also recovered with proloculi: about 0.10 mm. in diameter. These presumably represent the megalospheric generation. (Plate 17, fig. 4c).

Variation.—There is variation in the height of the spire and the shape of the apertural face.

Discussion.—This species differs from *Gyroidina altispira* Cushman and Stainforth in its more flattened spire and slower rate of chamber size increase. It is also more inflated and distinguished

by having radial sutures. It is similarly distinguished from Reuss' species *G. soldanii, G. girdans,* and *G. nitida* and their allies. The species differs from the nearly related *Gyroidina byramensis* Cushman and Todd, from the Mississippi Oligocene, in its inflation, depressed chambers and distinct, deep umbilicus. The small umbilicus distinguishes it from *Gavelinella lellingensis* Brotzen, in addition to its fewer chambers in each whorl and the different shape of the apertural face.

Genus **Eponides** Montfort, 1808

Eponides? aff. **E. toulmini** Brotzen

Plate 17, figures 7-7b; Plate 18, figure 2.

See 1948, *Eponides toulmini* Brotzen, Sver. Geol. Undersok., Ars. 42, ser. c, no. 493, p. 78, pl. 10, fig. 16.

Description.—Test with dorsal side evolute, flattened, ventral side high, involute; periphery subacute; chambers 15, 5:5:5, in successive whorls; sutures swept back, markedly so on the dorsal side; aperture ventral at the middle of the basal suture, without a lip; ventral umbilicus covered by a projecting lobe of the last chamber; wall granular; both sides show small round pores and large scattered pores with sieve plates and plugs.

Dimensions.—Diameter 0.27 mm.; width 0.15 mm.

Horizon.—RB1, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42592 and P42593.

Discussion.—The Thanet specimens differ from the population of the Swedish Paleocene in lacking a keel and in the pronounced lobe which fills the ventral umbilicus. In addition coarse pores occur on both sides of the test as, in fact, they appear to do in the specimen figured by Brotzen, contrary to his diagnosis. It is possible that coarse perforation comes in on the ventral side with later chambers of the megalospheric generation.

This species differs from the typical *Eponides* in its granular wall, coarse perforation and in the slight indentation of the apertural face near and parallel to the periphery.

Subfamily ANOMALININAE

Genus **Hollandina** Haynes, n. gen.

Genotype *Hollandina pegwellensis* Haynes, n. sp.

Generic characters.—*Hollandina* includes anomalinids which have granular wall structure, are biconvex, involute ventrally, without ventral umbilicus, with coarse dorsal pores, swept back dorsal sutures and a ventro-peripheral aperture at the basal suture of the last chamber.

The genus differs from *Cibicidoides* in its aperture which does not run onto the dorsal side and in its low scimitar-shaped chambers on the dorsal side which resemble those of *Eponides.* It differs from *Eponides* in its granular test, in the position of its aperture (and its foramina which are also basal and towards the periphery) and in its large dorsal pores.

Hollandina pegwellensis Haynes, n.sp.

Plate 17, figures 5-5g

?1897, *Truncatulina haidingerii* (Burrows and Holland) (not d'Orbigny), Proc. Geol. Assoc., vol. 15, p. 47.

Distinguishing features.—A biconvex or dorsally high *Hollandina* with about nine chambers in the second whorl of microspheric specimens and seven or eight in the second whorl of megalospheric specimens. The ventral side tends to be flattened and the angle between the apertural face and the early part of the whorl is seen as a strong warping of the periphery in side view.

Description.—(Plate 17, figs. 5-5b). Test biconvex, dorsal side evolute, ventral side involute; periphery acute, semi-lobate, undulating in side view; chambers 25, 7:9:9: in successive whorls, slowly increasing in size; sutures swept back, markedly on the dorsal side, flush; apertural face weakly developed; aperture ventro-peripheral beneath a lip which just runs over the periphery; wall granular; pores minute on both sides with coarse pores in addition on the dorsal side.

Dimensions.—Diameter 0.27 mm.; width 0.13 mm.; proloculus diameter about 0.014 mm. Chambers become twice as long as high by the twentieth chamber.

Horizon.—P39, Pegwell Marls.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42605. Additional specimens, P42609.

Alternation of generations.—Over a hundred specimens from horizon P39 were examined. About sixty showed the proloculus clearly when immersed in xylene and three size groups could be distinguished, the first two groups in almost equal numbers, the third being rare.

1. Proloculi about 0.01 mm. to 0.015 mm. in diameter.

2. Proloculi about 0.02 mm. to 0.025 mm. in diameter.
3. Proloculi about 0.03 mm. to 0.037 mm. in diameter.

In group 1 the length of the chambers on the dorsal side relative to height increases slowly. Generally the length is not more than twice the height at the twentieth chamber. (N.B. Length being measured between the acute angles made by the sutures, height being measured perpendicularly to the length). This is reflected in the number of chambers in each whorl, generally 7:9:9, or 7:9:8, up to a maximum of approximately 27 in all.

In group 2 the length of the chambers becomes twice the height by about the thirteenth chamber and the total number reached is about 22, 7:8:7, or 7:7:7, in successive whorls.

In group 3 the development of the chambers is as in group 2 but in most cases examined reaching a lower total number.

These groups may represent the B1, A1 and A2 generations of Hofker.

Variation.—There is considerable variation in the height of the dorsal side and in the development of the apertural face and thus the warping of the periphery.

Discussion.—*Eponides cocoaensis* Cushman has a similar aperture to the Thanet species and may belong to the new genus.

Derivation of name.—The specific name refers to the type locality of the Thanet Formation. The genus is named in honour of R. Holland, one of the pioneer workers on the Thanet Beds.

Subfamily SIPHONININAE

Two views have been developed on the position of *Siphonina*. On the one hand the genus is considered to be allied to *Epistomina*, on the other to be nearer to the Anomalininae.

Brotzen (1948) referring to the aperture of *Siphonina* states, "such apertural shapes occur only in *Epistomina*." *Siphonina* in his view is an end stage in the evolution of the Epistominidae. This view is followed by Sigal (1952) and agrees with that of Cushman (1948) who placed *Epistomina* with *Siphonina* but placed the Siphonininae under his Rotaliidae

Glaessner (1945) separated *Siphonina* from *Epistomina* and placed the Siphonininae under his Discorbidae together with the Anomalininae. Hofker (1951) places *Siphonina* near the *Cibicides* group. He supposes *Siphonina* may have been derived from his Cibicidae through *Parrella* and draws attention to the "opaque" walls and coarse pores.

The character of the Thanet species *Pulsiphonina prima* (Plummer) appears to support the views of Glaessner and Hofker. There is no internal tooth structure and the test is granular with chains of large pores with small ones between on the dorsal side. *Siphonina* differs from the sub-genus *Pulsiphonina* in possessing a well developed apertural neck. Wood has shown *Siphonina* to be a radiate hyaline genus. If its ancestor is the granular *Pulsiphonina* this would appear to support the idea of a relation with the Anomalininae (which includes granular, coarsely porous species) rather than with the finely porous, radiate Epistominidae.

Bermudez (1952) has included *Charltonina* in the Siphonininae on the grounds of its ventro-peripheral aperture beneath a lunate flap. The Thanet species *Charltonina canterburyensis*, n. sp. is radiate hyaline with characteristic scattered pores. There is no internal tongue. This genus, recorded previously only from the Upper Cretaceous and Paleocene of Cuba, would appear to be related to the Siphonininae but stands apart from the *Pulsiphonina, Siphonina* line.

Genus **Siphonina** Reuss, 1850

Siphonina aff. **S. wilcoxensis** Cushman

Plate 17, figures 8-8b

See 1927, *Siphonina wilcoxensis* Cushman, U. S. Nat. Mus. Proc., vol. 72, p. 3, pl. 2, figs. 1-3.

Description.—Test biconvex, dorsal side evolute, raised, ventral side involute; periphery acute; 4 chambers visible ventrally; dorsal sutures flush and swept back; ventral sutures impressed; aperture elongate, in the apertural face parallel to the periphery; wall structure doubtful; pores coarse on the dorsal side.

Dimensions.—Diameter 0.21 mm.

Horizon.—RB3, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42627.

Discussion.—The single specimen recovered does not show the serrate periphery of Cushman's species and is highest dorsally rather than ventrally. The number of chambers visible at the periphery is four, not six, but one of Cushman's specimens from the Ozark Wilcox shows four and a half chambers at the periphery also.

Subgenus **Pulsiphonina** Brotzen, 1948

Pulsiphonina prima (Plummer)

Plate 17, figures 9-9b.

1927, *Siphonina prima* Plummer, Texas Univ. Bull., no. 2644, p. 148, pl. 12, fig. 4.

1940, *Siphonina prima* Cushman, Contr. Cush. Lab. Foram. Res., vol. 16, p. 71, pl. 12, fig. 10.

1942, *Siphonina prima* Cushman and Todd, Contr. Cush. Lab. Foram. Res., vol. 18, p. 40, pl. 7, figs. 16-17.

1944, *Siphonina prima* Cooper, Journ. Pal., vol. 18, no. 4, p. 353, pl. 55, figs. 7-9.

1946, *Siphonina prima* Cushman and Todd, Contr. Cush. Lab. Foram. Res., vol. 22, p. 62, pl. 11, figs. 7, 8.

1946, *Siphonina prima* Cushman, U. S. Geol. Surv. Prof. Paper 206, p. 143, pl. 59, figs. 3-5.

1951, *Siphonina prima* Cushman, U. S. Geol. Surv. Prof. Paper 232, p. 55, pl. 15, figs. 7-9.

Distinguishing features.—A compressed, biconvex *Pulsiphonina* with four or five chambers in each whorl and small lunate aperture without lips.

Description.—Test biconvex, compressed, dorsal side evolute, ventral side involute; periphery acute; chambers 13, 6:5:2—, in successive whorls, increasing rapidly in size, 4 visible at the periphery and on the ventral side; sutures swept back, mark-

EXPLANATION OF PLATE 17

Figs.		
1-1b.	*Gyroidina? danvillensis* var. *gyroidinoides* (Bandy) X50. 1b, ventral view.	93
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5-5g.	*Hollandina pegwellensis* Haynes, n.sp. X50. 5 to 5b, microspheric specimen, 5b, dorsal view; 5c to 5e and 5f, 5g, megalospheric specimens.	94
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8-8b.	*Siphonina* aff. *wilcoxensis* Cushman. X50. 8b, ventral view.	95
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10-10b.	*Globigerinella aspera* (Ehrenberg). X50.	98
11-11b.	*Globigerina triloculinoides?* Plummer. X50. 11b, ventral view.	99
12-12b.	*Globigerina pseudobulloides* Plummer. X50. 12b, ventral view.	99
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14-14b.	*Charltonina canterburyensis* Haynes, n.sp. X100. 14a, ventral view.	97
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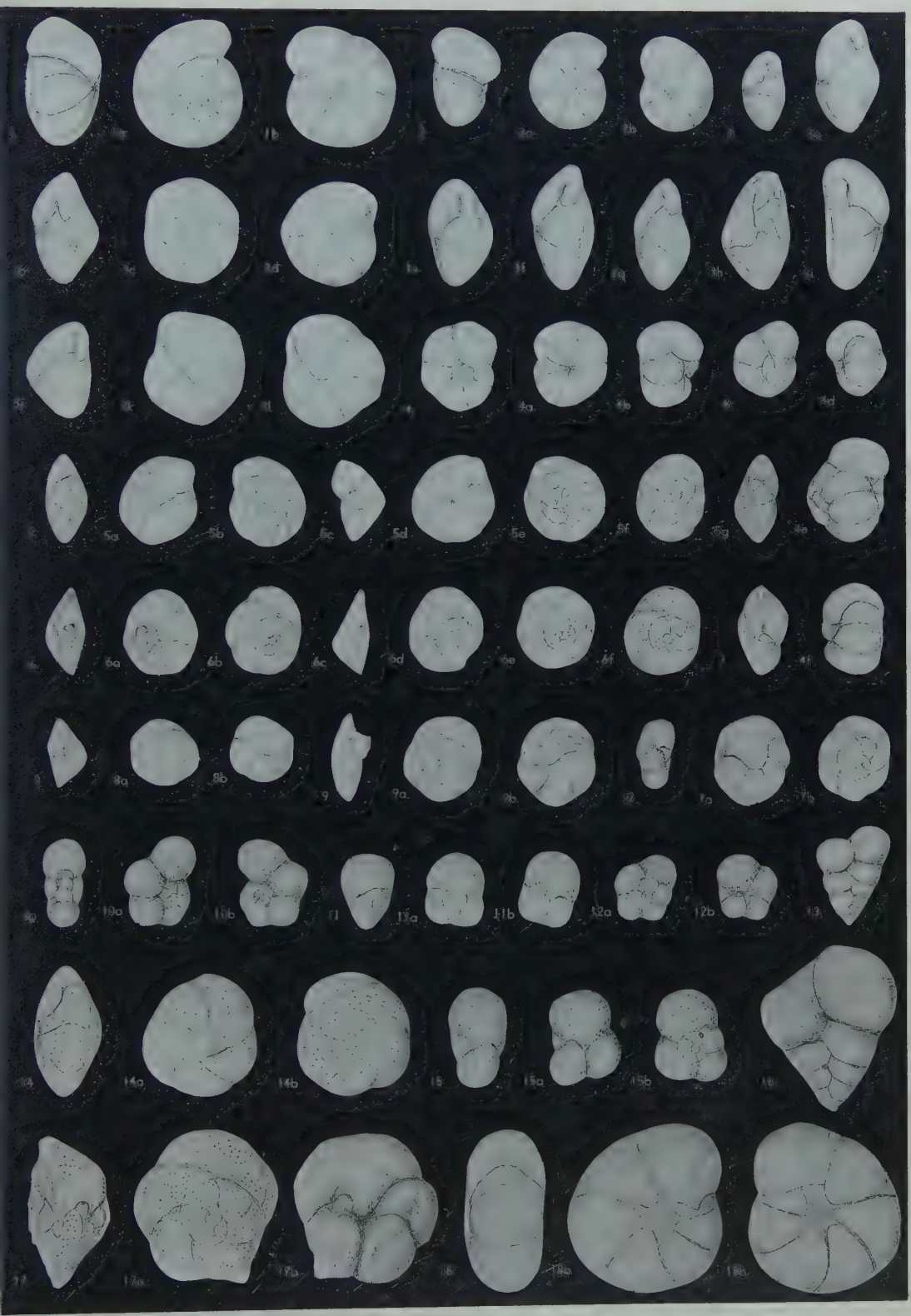
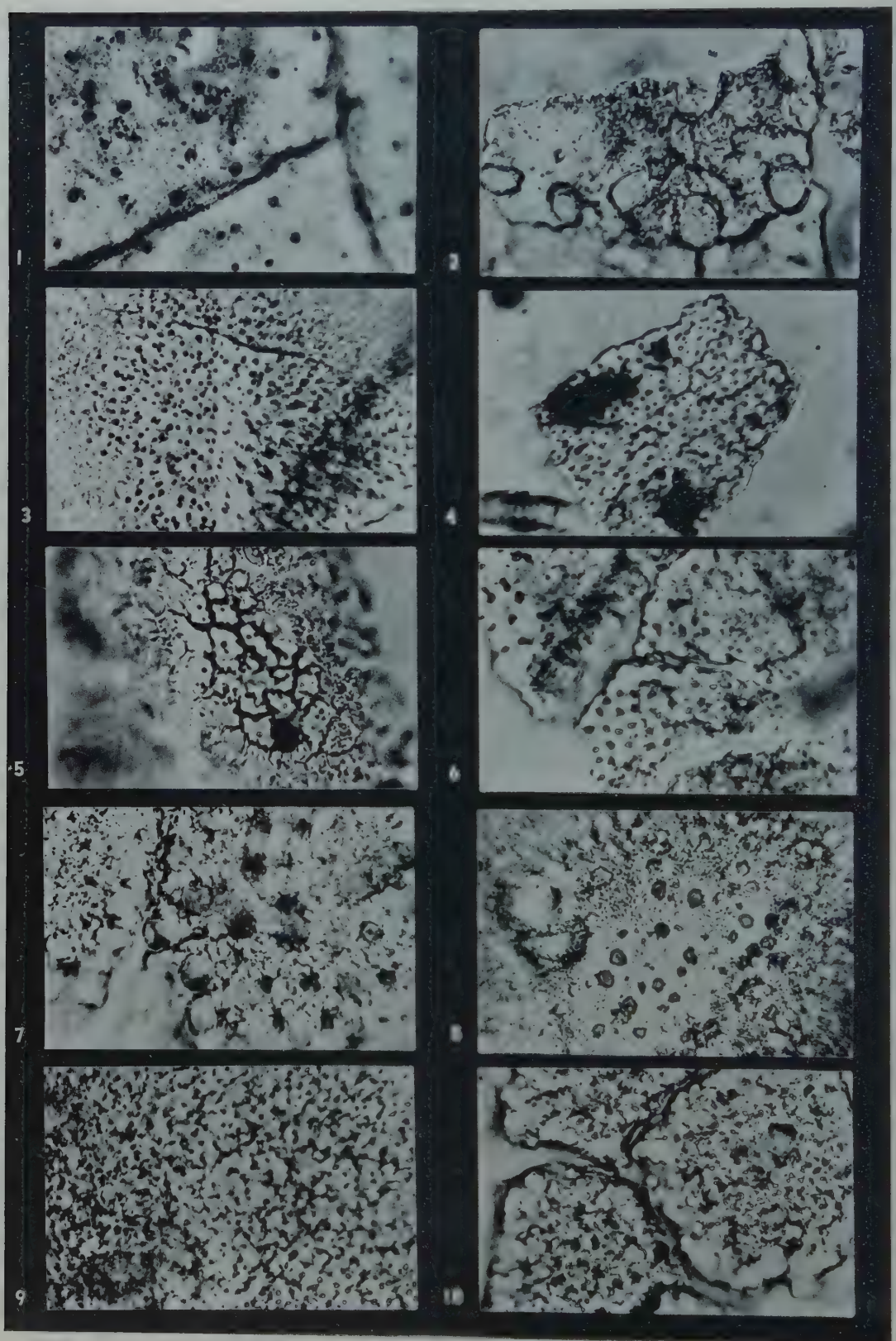


Haynes: British Paleocene Foraminifera



Haynes: British Paleocene Foraminifera

edly so on the dorsal side, slightly impressed on the ventral side; aperture an elongate curved slit in the median plane near the periphery and above the basal suture; test granular; pores minute on the ventral side; chains of large pores along the keel on the dorsal side.

Dimensions.—Diameter 0.27 mm.; proloculus 0.025 mm. in diameter; Chambers become about three times as long as high by the third whorl.

Horizon.—P48, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42626.

Range.—Paleocene (Midway) Texas, Alabama, Arkansas; Possibly Upper Cretaceous, Texas.

Genus **Charltonina** Bermudez, 1952

Charltonina canterburyensis Haynes, n. sp.

Plate 17, figures 14-14b

Distinguishing features.—A minute, biconvex *Charltonina* with up to five whorls of chambers with five chambers in each. The periphery is rounded and there is a ventral umbo.

Description.—Test biconvex, ventral side involute, dorsal side evolute; periphery sub-round; chambers about 24, in about 4½ whorls, 5½ chambers visible ventrally; sutures swept back, markedly so on the dorsal side, impressed on the ventral side; aperture ventral and peripheral beneath a lunate flap which curves up from the basal suture into the apertural face parallel to the periphery; wall radiate; pores scattered, possibly with very small ones between.

Dimensions.—Diameter 0.18 mm.; width 0.09 mm.

Horizon.—P16, Pegwell Marls.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42628. Additional specimens P42629.

Discussion.—This species differs from the genotype *C. madrugaensis* (Cushman and Bermudez) in its small size, rounded periphery and ventral umbo. Proloculus size groups could not be made out in the Thanet species.

Family AMPHISTEGINIDAE

Genus **Asterigerina** d'Orbigny, 1839

Asterigerina aberystwythi Haynes, n. sp.

Plate 17, figures 6-6f

Distinguishing features.—A carinate, biconvex or sub-conoidal *Asterigerina* in which the number of chambers tends to be reduced to four in the third whorl of megalospheric forms, five in the third whorl of microspheric forms. The ventral surface is tuberculate, up to half the surface being covered, and the supplementary chamberlets are small.

EXPLANATION OF PLATE 18

FIGS.

Magnification of all figures X770

1. Internal view of small round pores with minute pores scattered between in *Gyroidinoides voluptus.* 93
2. Internal view of large (apparently plugged) pores with minute round pores scattered between in *Eponides?* aff. *toulmini.* 94
3. Dense round pores in *Protelphidium hofkeri* external view. 86
4. Internal view of dense round pores in *Nonion applinac* 85
5. Small round pores in *Nonionella robusta* var. *perdita,* external view. 83
6. Dense round pores in *Rosalina koeneni,* internal view. 91
7. External view of large irregular pores with minute pores between in *Globigerinella aspera,* the fuzzy outline of tubercles, out of focus, can also be seen. 98
8. External view of very dense, very small pores in *Ceratobulimina tuberculata* with tubercles in black outline. 90
9. Dense round pores, some apparently coalescing in *Gyroidina? danvillensis* var. *gyroidinoides,* external view. 93
10. Large irregular pores with very small ones between (apparently coalescing, possibly weathered) in *Globigerina pseudobulloides.* The fuzzy outline of tubercles, out of focus, can also be seen. 99

Description.—(Plate 17, figs. 6-6b). Test biconvex, dorsal side evolute, ventral side involute; periphery carinate; chambers 14, 7:5:2—, in successive whorls, 4½ visible ventrally; sutures swept back, markedly on the dorsal side, slightly impressed ventrally; aperture ventral at the middle of the basal suture, oval with a slight lip; on the umbilical side the lip curves over and passes into a tooth; previous chambers show internal plates which join the septa of previous chambers about a third of the way from the umbilicus to the periphery; wall radiate; pores round, small and dense; ventral side below the aperture tuberculate.

Dimensions.—Diameter 0.26 mm.; width 0.16 mm.; the chambers become more than twice as long as high by the close of the second whorl; proloculus about 0.023 mm. in diameter.

Horizon.—P50, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42630. Additional specimens P42631.

Alternation of generations.—There appear to be at least three groups of proloculus size:—

1. with proloculus diameters about 0.008 mm. tends to develop up to nineteen chambers, 6 or 7: 6:5:1—, in successive whorls, with 4 to 5 visible ventrally.

2. with proloculus diameters about 0.015 mm. to 0.018 mm. tends to develop up to seventeen chambers, 6 or 7: 5 or 6: 4—, with 4 visible ventrally.

3. with proloculus diameters about 0.025 mm. tends to develop up to fourteen chambers, 6 or 7: 5: 2—, with 4 visible ventrally.

These groups may represent Hofker's B1, A1, and A2 generations.

Variation.—Variation occurs in the height of the dorsal side and in the amount of tuberculation.

Discussion.—The Thanet species differs in its ornament and smaller supplementary chamberlets from *A. primaria* Plummer and *A. bracteata* Cushman, and in its high dorsal side from *A. carinata* d'Orbigny. *A. gurichi* Franke shows more chambers in each whorl in all generations.

Derivation of name.—The name was given because the work was done in the micropaleontological laboratories of the University College of Wales, Aberystwyth.

Family GLOBIGERINIDAE

Three species belonging to the family Globigerinidae were recovered from the Thanet Beds. These species are radiate in wall structure and show large irregular pores with smaller pores between them (Plate 18, figs. 7 and 10). The large pores appear to have absorbed smaller pores at their edges.

Genus **Globigerinella** Cushman, 1927

Globigerinella aspera (Ehrenberg)

Plate 17, figures 10-10b; Plate 18, figure 7

1854, *Phanerostomum asperum* Ehrenberg, Mikrogeologie, pl. 30, figs. 26a, b, pl. 32, pt. 2, fig. 42.

1907, *Globigerina asperum* Egger, Microfauna der Kreide . . ., Ber. Nat. Ver. Passau., p. 49, pl. 7, fig. 27.

1929, *Globigerinella aspera* Carman, Journ. Pal., vol. 3, p. 315, pl. 34, fig. 6.

1931, *Globigerinella aspera* Cushman, Tenn. Div. Geol. Bul. 41, p. 59, pl. 11, figs. 5, a, b.

1936, *Globigerinella aspera* Brotzen, Sver. Geol. Under., Ars. 30, no. 3, p. 170, pl. 13, figs. 2a-c.

1941, *Globigerinella aspera* Marie, Mus. Nat. Hist., Mem. tome 12, fas. 1, p. 235, pl. 36, fig. 336.

1948, *Globigerinella aspera* Brotzen, Sver. Geol. Undersok., Ars. 42, no. 2, p. 90 (listed only).

Distinguishing features.—A *Globigerinella* with high peripheral aperture, six chambers in the second whorl of what appear to be megalospheric specimens, deeply impressed sutures and spinose surface.

Description.—Test biconvex, sub-globular; periphery rounded, lobate; chambers 13, 7:6, in successive whorls; sutures radial, deeply impressed; aperture at the periphery in the median plane, high, oval beneath a lip; wall radiate, pores irregular with smaller pores between and at their edges; spinose.

Dimensions.—Diameter 0.25 mm.; width 0.11 mm.; proloculus about 0.015 mm. in diameter; height of chamber at the close of the second whorl about four times that at the close of the first whorl.

Horizon.—RB19, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42632.

Discussion.—No proloculus size groups were observed.

Range.—Upper Cretaceous, U. S. A., Germany, France, Sweden, Netherlands, Paleocene, Sweden.

Genus **Globigerina** Orbigny, 1826

Globigerina pseudobulloides Plummer

Plate 17, figures 12a, 12b. Plate 18, figure 10

1926. *Globigerina pseudobulloides* Plummer, Univ. Tex. Bull., no. 2644, p. 133, pl. 8, figs. 9a-c.

1930, *Globigerina pseudobulloides* Nuttall, Journ. Pal., vol. 4, no. 3, p. 290.

1937, *Globigerina pseudobulloides* Glaessner, Mosc. Univ. Paper, vols. 2-3, p. 382, pl. 4, fig. 31.

1940, *Globigerina pseudobulloides* Cushman, Contr. Cush. Lab. Foram. Res., vol. 16, p. 72, pl. 12, fig. 16.

1942, *Globigerina pseudobulloides* Cushman and Todd, Contr. Cush. Lab. Foram. Res., vol. 18, p. 43, pl. 8, figs. 3-4.

1948, *Globigerina pseudobulloides* Brotzen, Sver. Geol. Under., Ars. 42, no. 2, p. 90 (listed only)

1951, *Globigerina pseudobulloides* Cushman, U. S. Geol. Surv. Prof. Paper, no. 232, p. 60, pl. 17, figs. 7, 8.

1952, *Globigerina pseudobulloides* Bronnimann, Bull. Amer. Pal., vol. 34, no. 143, p. 21, pl. 3, figs. 7-9.

Distinguishing features.—A *Globigerina* with low spire and five inflated chambers in adult whorls. The aperture is arcuate with a lip and opens into the umbilicus.

Description.—Test sub-globular, ventral side involute, dorsal side evolute; periphery rounded, lobate; chambers 13, 6:5:2—, in successive whorls; sutures impressed, curved in initial part, radial in adult; aperture oval, beneath a lip, opening into the umbilicus; wall radiate; pores irregular with smaller pores between; spinose.

Dimensions.—Diameter 0.2 mm.; width 0.12 mm.; height of chambers at close of the second whorl almost twice that at the close of the first whorl; proloculus about 0.01 mm. in diameter.

Horizon.—RB19, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42633.

Discussion.—The Thanet specimens appear to be less well grown than the original types, both otherwise identical.

Range.—Paleocene, Sweden, Caucasus, (Midway) Texas and Arkansas, (Naheola) Alabama, (Lizard Springs Marl) Trinidad, (Velasco) Florida.

Globigerina triloculinoides Plummer

Plate 17, figs. 11-11b, 15-15b

1926, *Globigerina triloculinoides* Plummer, Univ. Tex. Bull., No. 2644, p. 134, pl. 8, fig. 10.

1936, *Globigerina triloculinoides* Jennings, Bull. Amer. Pal., vol. 23, no. 78, pp. 159-234 (1-76), pls. 28-34 (1-7).

1937, *Globigerina triloculinoides* Glaessner, Mosc. Univ. Paper, vols. 2-3, p. 382, pl. 4, fig. 33.

1940, *Globigerina triloculinoides* Cushman, Contr. Cush. Lab. Foram. Res., vol. 16, p. 72, pl. 12, fig. 15.

1941, *Globigerina triloculinoides* Toulmin, Journ. Pal., vol. 65, p. 607, pl. 82, fig. 3.

1942, *Globigerina triloculinoides* Cushman and Todd, Contr. Cush. Lab. Foram. Res., vol. 18, figs. 1, 2.

1944, *Globigerina triloculinoides* Cooper, Journ. Pal., vol. 18, no. 4, p. 343.

1946, *Globigerina triloculinoides* Cushman and Todd, Contr. Cush. Lab. Foram. Res., vol. 22, p. 64.

1951, *Globigerina triloculinoides* Cushman, U. S. Geol. Surv. Prof. Paper, no. 232, p. 60, pl. 17, figs. 10, 11.

1952, *Globigerina triloculinoides* Bermudez, Min. de Minas and Hidrocarburos, Bol. Geol., vol. 2, no. 4, p. 24, pl. 3, figs. 13-18.

1955, *Globigerina triloculinoides* Weiss, Micropaleontology, vol. 1, no. 4, p. 308, pl. 1, figs. 18-21.

Distinguishing features.—A *Globigerina* with low spire and three and a half chambers in adult whorls. The aperture is low, towards the umbilicus and covered by a lip.

Description.—(Plate 17, figs. 15-15b). Test biconvex, ventral side involute, dorsal side evolute; periphery rounded, lobate; chambers 9, 5:4, in successive whorls, increasing rapidly in size; sutures backward curving in the initial part, becoming radial and impressed; aperture low, beneath a lip, opening into the umbilicus; wall radiate; pores irregular with smaller pores between.

Dimensions.—Diameter 0.20 mm.; width about 0.10 mm.; height of last chamber about three times that at the close of the first whorl.

Horizon.—RB18, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42634.

Discussion.—One specimen was found, (Plate 17, figs. 11-11b) with less impressed sutures and more depressed chambers, that may be nearer *G. linaperta* Finlay.

The specimens recorded as *G. bulloides* (d'Orbigny) by Burrows and Holland probably belonged to this species.

Range.—Paleocene, Sweden, (Midway) Texas,

Alabama, and Arkansas, (Wilcox) Alabama, (Lizard Springs Marl) Trinidad, Caucasus. Danian, Sweden.

Family GLOBOROTALIIDAE

Genus **Globorotalia** Cushman, 1927

Globorotalia velascoensis (Cushman) aff. var. **acuta** (Toulmin)

Plate 17, figures 17-17b.

See 1951, *Globorotalia velascoensis* (Cushman) var. *acuta* (Toulmin) Grimsdale, Rep. Proc. 3rd World Petr. Cong., Sect. 1, p. 471.

Description.—Test almost plano-convex, ventral side high, involute, raised towards the umbilicus, dorsal side evolute; periphery acute; chambers 11, 6:5:-, 4 being visible ventrally; sutures backward curving on the dorsal side, limbate with tubercles, impressed on the ventral side; last chamber broken, previous foramen oval, at the umbilicus; wall radiate; pores minute.

Dimensions.—Diameter 0.23 mm.; width 0.13 mm.

Horizon.—RB19, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42635.

Discussion.—The Thanet specimens appear to be a variety of *G. velascoensis* Cushman with about four and a half chambers visible at the periphery and are thus near var. *acuta* Toulmin but differ in possessing slightly raised dorsal sides and beaded dorsal sutures. Grimsdale, in his discussion, states in reference to the beaded sutures, lacking in var. *acuta* and the smoother test, "these two latter features are of doubtful significance for taxonomic purposes within a single species".

Family GÜMBELINIDAE

Gümbelina cf. **G. striata** (Ehrenberg)

Plate 17, figure 16

See 1946, *Gümbelina striata* Cushman, U. S. Geol. Surv. Prof. Paper, no. 206, p. 104, pl. 45, figs. 4,5.

Description.—Test biserial, compressed, greatest width at the apertural end; chambers 9, increasing steadily in size; sutures straight; aperture low at the basal suture; ornament of fine, longitudinal costae; wall silicified.

Dimensions.—Length 0.25 mm.; maximum width 0.21 mm.

Horizon.—RB15, Reculver Silts. (Presumed derived).

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42636.

Discussion.—According to Cushman the typical *G. striata* shows costae which gradually fade out with growth. The Thanet specimen differs in this character and is more flaring with less spherical chambers.

Gümbelina globulosa (Ehrenberg)

Plate 17, figure 13.

1840, *Textilaria globulosa* Ehrenberg, K. Akad. Wiss. Berlin, p. 135, pl. 4, figs. 216, 71b, 81b.
1854, *Textilaria globulosa* Ehrenberg, Mikrogeologie, pl. 21, fig. 87.
1899, *Gümbelina globulosa* Egger, Abh. K. Bayer. Akad. Wiss. kl. 2, vol. 21, pt. 1, p. 32, pl. 14, fig. 43.
1926, *Gümbelina globulosa* Chapman, N.Z. Geol. Surv. Pal. Bull., no. 11, p. 33, pl. 8, fig. 5.
1927, *Gümbelina globulosa* Cushman, Contr. Cush. Lab. Foram. Res., vol. 3, p. 190.
1929, *Gümbelina globulosa* Carman, Journ. Pal., vol. 3, p. 312, pl. 34, figs. 10-20.
1929, *Gümbelina globulosa* White, Journ. Pal., vol. 2, p. 36, pl. 4, figs. 10a, b.
1931, *Gümbelina globulosa* Cushman, Tenn. Div. Geol. Bull. 41, pl. 7, figs. 3-5.
1932, *Gümbelina globulosa* Cushman, Journ. Pal., vol. 6, p. 338.
1944, *Gümbelina globulosa* Cushman and Deaderick, Journ. Pal., vol. 18, p. 336, pl. 53, figs. 2,3.
1946, *Gümbelina globulosa Cushman,* U.S. Geol. Surv. Prof. Paper, 206, p. 105, pl. 45, figs. 9-15.

Distinguishing features.—A smooth, tapering *Gümbelina,* up to twice as long as broad with up to seventeen chambers slowly increasing in size and becoming spherical.

Description.—Test elongate, tapering, sub-globular; chambers 12, steadily increasing in size and becoming globular; sutures impressed; aperture long and low at the inner margin of the last chamber; wall silicified.

Dimensions.—Length 0.31 mm.; maximum width 0.22 mm.

Horizon.—RB2, Reculver Silts. (Presumed derived).

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42636.

Range.—Upper Cretaceous (Navarro and Taylor) of America. (Senonian and Maestrichtian) of Europe.

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH

VOLUME VII, PART 3, JULY, 1956

RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the Foraminifera that have come to hand.

ALEXANDROWICZ, S. **Globotruncana** assemblages in the Turonian of the Cracow region (in Polish with English summary).—Acta Geol. Polonica, v. 6, No. 1, 1956, p. 41-63, text figs. 1-12, tables 1, 2.—Eight species (and subspecies), none new, identified in thin section.

ALIZADE, K. A. Akchagyl formation of Azerbaijan.—Baku, 1954, 344 p., 19 pls.—A few species of Foraminifera are illustrated from Tertiary strata.

ARNOLD, ZACH M. Life history and cytology of the foraminiferan **Allogromia laticollaris.**—Univ. Calif. Publ. Zoöl., v. 61, No. 4, 1955, p. 167-252, pls. 27-35, text figs. 1-3.

ASANO, KIYOSHI. The Foraminifera from the Adjacent Seas of Japan, collected by the S. S. Soyomaru, 1922-1930. Parts 1 and 2, Nodosariidae and Miliolidae.—Sci. Repts. Tohoku Univ., Sendai, Japan, 2nd ser. (Geol.), v. 27, 1956, p. 1-83, pls. 1-9, text figs. 1-5.—In the two parts a total of 135 species, of which 8 are described as new, are recorded and illustrated from collections on the continental shelf.

AUROUZE, GERMAINE, and BOULANGER, DOMINIQUE. Sur une variété de **Ganella neumannae** dans le Lutétien inférieur de Chalosse.—Soc. Géol. France C. R. S. séance du Dec. 19, 1955, No. 16, p. 334-336, text figs. 1-3.—An evolute variety, **exponens.**

BIELECKA, WANDA. Znaczenie Stratygraficzne Otwornic (in Polish).—Przeglad Geologiczny, Zeszyt Nr. 1, 1953, p. 38-42, text figs. 1-5.—Stratigraphic range charts of families, genera, and species.

Investigations of microfauna of the Lower Malm in the vicinity of Trzebinia (Upper Silesia) (in Polish with English summary).—Poland Instyt. Geol., Biul. 102, 1956, p. 59-80, pl. 4.—Seven zones of local significance are based on Foraminifera. Range and abundance are indicated for 72 species.

Note on Triassic foraminifers of the north-west periphery of the Swiety Krzyz Mountains (in Polish with English summary).—Poland Instyt. Geol., Biul. 102, 1956, p. 81-95, pl. 5, text figs. 1, 2. — Undetermined arenaceous Foraminifera, mostly **Haplophragmoides.**

BLOW, W. H. Origin and evolution of the foraminiferal genus **Orbulina** d'Orbigny.—Micropaleontology, v. 2, No. 1, January 1956, p. 57-70, text figs. 1-4.—Evolution from **Globigerinoides triloba** through **G. bispherica** into 2 independent lines, one line ultimately becoming **Orbulina universa,** the other **Biorbulina** n. gen. (genotype **Globigerina bilobata** d'Orbigny, 1846). Two new species (one including 3 subspecies) of **Globigerinoides** are described. The study is based on material from Trinidad and Venezuela.

BOLIN, EDWARD J. Upper Cretaceous Foraminifera, Ostracoda, and Radiolaria from Minnesota.—Journ. Pal., v. 30, No. 2, March 1956, p. 278-298, pls. 37-39, text figs. 1-5.—Foraminifera comprise a part of the basis of correlation of outcrop material with the Niobrara formation. Subsurface material is tentatively determined as Cenomanian in age. Twenty-one species of Foraminifera, 6 new and 6 indeterminate, are described and illustrated.

BOURDON, MARC, and LYS, MAURICE. Foraminifères du Stampien de la carrière de la Souys-Floirac (Gironde).—Soc. Géol. France C. R. S. séance du Dec. 19, 1955, No. 16, p. 336-338, text figs. 1, 2.—**Arenagula** n. gen. (genotype **A. globula** n. sp.), distinguished from **Cribrobulimina** in having 5 chambers in the initial whorl; and **Valvulineria latidorsata** n. sp.

BURGL, H. La Formacion Guadalupe entre Tabio y Chia en la Sabana de Bogotá.—Colombia Instit. Geol. Nac., Bol. Geol., v. 3, No. 2, 1955, p. 23-55, pls. 5-8.—Species of **Siphogenerinoides** recorded. **Globorotalia fohsi** en la formacion de Usme.—Colombia Instit. Geol. Nac., Bol. Geol., v. 3, No. 2, 1955, p. 56-65, text fig. 1.—**G. fohsi andina** n. subsp. described and the age of strata considered late middle to early upper Oligocene.

CITA, MARIA BIANCA. Studi stratigrafici sul Terziario subalpino lombardo. Nota V. Paleografia del Terziario nella regione Gardesana.—Riv. Ital. Pal. Stratig., v. 61, No. 3, 1955, p. 1-25, map, columnar sections.—Strata ranging from Upper Cretaceous to Pleistocene are characterized by Foraminifera.

COLE, W. STORRS. Jamaican Larger Foraminifera.—Bull. Amer. Pal., v. 36, No. 158, May 8, 1956, p. 201-233, pls. 24-31, tables 1-6.—Lists and illustrations of numerous species, 2 new, from localities of middle Eocene to Miocene age.

The genera **Miscellanea** and **Pellatispirella.**—Bull. Amer. Pal., v. 36, No. 159, May 15, 1956, p. 235-254, pls. 32-34, text fig. 1.—**Miscellanea** a camerinid. **Pellatispirella** closely related to **Elphidium.**

CRESPIN, IRENE. Distribution of Lower Cretaceous Foraminifera in Bores in the Great Artesian Basin, northern New South Wales.—Journ. Proc. Royal Soc. New South Wales for 1955, v. 89, pt. 1, 1956, p. 78-84, map, tables 1, 2.—About 100 species are included in a distribution table and 3 zones are recognized.

CUVILLIER, J., DALBIEZ, F., GLINTZBOECKEL, C., LYS, M., MAGNE, J., PEREBASKINE, V., and REY, M. Etudes micropaléontologiques de la limite Crétacé-Tertiaire dans les mers mesogeennes.—Proc. Fourth World Petr. Congress, sec. I/D, paper 6, 1955, p. 517-544, pls. 1, 2, text fig. 1, tables 1-6, 4 maps.—Includes tables showing stratigraphic ranges of certain critical Foraminifera that are characteristic of the Cretaceous-Tertiary transition beds in Morocco, Algeria, Tunis, and Lebanon. End of Cretaceous marked by disappearance of **Globotruncana** and **Rugoglobigerina** and beginning of Tertiary marked by appearance of **Globorotalia (Truncorotalia),** with an intervening zone of **Globigerina** having mixed affinity

DROOGER, C. W. Remarks on **Cycloclypeus,** I and II.—Proc. Kon Nederl. Akad. Wetenschappen, ser. B, v. 58, No. 5, 1955, p. 415-433, text figs. 1-16.

Miogypsina at Puente Viejo, Spain.—Proc. Kon Nederl. Akad. Wetenschappen, ser. B, v. 59, No. 1, 1956, p. 68-72, text fig. 1.—Interpreted as shallow water material displaced into deep water **Globigerina** ooze.

Transatlantic correlation of the Oligo-Miocene by means of foraminifera.—Micropaleontology, v. 2, No. 2, April 1956, p. 183-192, pl. 1, text fig. 1.—Tentative correlation between miogypsinids and certain planktonics as based on European and North African data and tied in with the European time scale suggest that the Oligocene of Central American regions is synchronous with the early and middle Miocene of Europe.

ERICSON, DAVID B., and WOLLIN, GOESTA. Correlation of six cores from the Equatorial Atlantic and the Caribbean.—Deep-Sea Research, v. 3, No. 2, 1956, p. 104-125, text figs. 1-11, tables 1-6.—Curves of Pleistocene climatic variation are based on vertical distribution of planktonic Foraminifera, percentage of fine material (less than 74 microns), and coiling direction of **Globorotalia truncatulinoides.**

FOURNIER, GEORGE. New methods and techniques in the photography of microfossils.—Micropaleontology, v. 2, No. 1, Jan. 1956, p. 37-56, pls. 1-5, text figs. 1-4, charts 1, 2.

GANSS, ORTWIN, and KNIPSCHEER, H. C. G. Die Maastricht-Eozän-Folge des Helvetikums im Sprunggraben bei Oberteisendorf (Obb.) und ihre Gliederung mit Hilfe pelagischer Foraminiferen.—Geol. Jahrb., Band 71, March 1956, p. 617-630, text figs. 1, 2, table 1.—Lists of Foraminifera and

illustrations of 12 planktonic species used as age indicators.

GIUNTA, MARGHERITA. Studio delle microfaune contenute in cinque saggi di fondo prelevati presso S. Margherita Ligure e Chiavari (Genova).—Archiv. Oceanogr. e Limnol., v. 10, fasc. 1-2, 1955, p. 67-108, pls. 1, 2.—Analysis of 5 samples taken between 20 and 135 meters in the Ligurian Sea. Comparisons are made with other Recent faunas and with fossil faunas from nearby areas. Nineteen species are illustrated.

GOULD, HOWARD R., and STEWART, ROBERT H. Continental terrace sediments in the northeastern Gulf of Mexico.—Soc. Econ. Pal. Min., Spec. Publ. No. 3, Finding Ancient Shore lines, Symposium, 1955 (1956), p. 2-19, text figs. 1-6.—Five assemblages of Foraminifera: **Streblus** (shallow brackish), **Archaias** (0-17 fms.), **Hanzawaia** and **Planulina** (17-30 fms.), **Amphistegina** (30-58 fms.), and **Uvigerina** (58-100 fms.).

HAILE, N. S., editor. Geological accounts of West Borneo, translated from the Dutch.—Geol. Survey Dept., British Territories in Borneo, Bull. 2, 1955, 285 p., illust.—Both small and large Foraminifera are listed or mentioned by several of the authors as evidence for age determination.

HOFKER, JAN. Foraminifera from the Cretaceous of southern Limburg, Netherlands. VI. **Globorotalia (Truncorotalia) mosae** nov. spec. VII. **Nonionella cretacea** (Reuss) (non Cushman).—Natuurhist. Maandblad, 44e Jrg., No. 9-10, Oct. 28, 1955, p. 99-102, 3 text figs.—New **Globorotalia** from upper beds of Maestrichtian age. **Operculina cretacea** Reuss is a **Nonionella. Nonionella cretacea** Cushman is re-named **N. taylorensis.**

VIII. The genus **Allomorphina** in the Dutch Cretaceous.—Natuurhist. Maandblad, 44e Jrg., No. 9-10, Oct. 28, 1955, p. 103-106, 2 text figs.—Four species, none new, are described and illustrated.

IX. **Dictyoconus mosae** nov. spec. X. **Eponides involuta** nov. spec.—Natuurhist. Maandblad, 44e Jrg., No. 11-12, Dec. 30, 1955, p. 115-118, 3 text figs.—New species in upper beds of Maestrichtian age.

XI. **Rotalia trochidiformis** (Lamarck).—Natuurhist. Maandblad, 44e Jrg., No. 11-12, Dec. 30, 1955, p. 119-121, 1 text fig.—Occurrence in upper beds of Maestrichtian age supports their Tertiary age.

XII. **Gavelinella umbilicatiformis** nov. spec.—Natuurhist. Maandblad, 44e Jrg., No. 11-12, Dec. 30, 1955, p. 120, 122, 1 text fig.

XIII. **Cibicides bosqueti** (Reuss). — Natuurhist. Maandblad, 44e Jrg., No. 11-12, Dec. 30, 1955, p. 123-125, 2 text figs.

KAWADA, SHIGEMA. Stratigraphical and Palaeontological Studies of the Omi Limestone in the Mt. Kurohime District, Niigata Prefecture (in Japanese with English summary).—Misc. Repts. Research Instit. Nat. Resources, Tokyo, No. 35, Sept. 25, 1954, p. 48-56, text figs. 1-4, distrib. table.—The limestone is zoned by fusulinids.

Stratigraphical and Palaeontological Studies of the Omi Limestone in the Mt. Myojo District, Niigata Prefecture (in Japanese with English summary).—Misc. Repts. Research Instit. Nat. Resources, Tokyo, No. 36, Dec. 25, 1954, p. 39-48, text figs. 1-4, distrib. table.—The limestone is zoned by fusulinids.

KIRCHNER, ZBIGNIEW. Z Zagadnien Biostratygrafii Miocenu (in Polish).—Przeglad Geologiczny, Zeszyt Nr. 6, 1953, p. 1-8, tables 1-4.

KOPIK, JANUSZ. Stratigraphy and microfauna of the Jurassic in the "Borucice" deep bore-hole near Leczyca (district of Lodz) (in Polish with English summary).—Poland Instyt. Geol., Biul. 102, 1956, p. 31-58, pls. 2, 3.—A small fauna, mostly arenaceous species, was found in the Lower Dogger. Occurrence and abundance in the bore-hole is indicated for 45 species.

KUWANO, YUKIO. Notes on the genus **Cassidulina** and allied genera from Japan. I and II.—Misc. Repts. Research Instit. Nat. Resources, Tokyo, No. 34, June 1954, p. 78-81, text figs. 1-4; No. 35, Sept. 25, 1954, p. 33-36, text figs. 1-11.—Four new species and one variety: **C. nojimana, C. undata, C. crepidula, C. paratortuosa,** and **C. elegans** var. **bosoensis,** all from the Pliocene of southern Kwanto region.

LIPINA, O. A. Foraminifera of Tournaisian strata and upper part of Devonian of Volga-Ural region and western slopes of Middle Urals (in Russian).—Akad. Nauk SSSR, Instit. Geol. Nauk, Trudy, vyp. 163, 1955, p. 1-96, pls. 1-13, text figs. 1-7.—Russian descriptions and thin section photographs of numerous species, many new, mostly related to **Endothyra.** Several new genera are erected.

MAYNC, WOLF. On the age of the **Choffatella**-bearing beds in Venezuela.—Micropaleontology, v. 2, No. 1, Jan. 1956, p. 92.

MONTANARO GALLITELLI, EUGENIA. Qualche appunto sulla stratigrafia e la tettonica della regione de Castelvetro (Modena).—Atti e Mem., Accad. Sci. Lett. Arti di Modena, ser. 5, v. 12, 1954, p. 172-200, geol. map, distrib. table, text figs. 1-5.—Occurrence of numerous Foraminifera is recorded and used in working out Late Tertiary tectonic relationships.

Marne ed argille a **Schackoina** e **Gümbelina** nella formazione a Fucoidi ed Elmintoidee di Serramazzoni (Modena).—Atti e Mem., Accad. Sci. Lett. Arti di Modena, ser. 5, v. 12, 1954, p. 201-210, pls. 1, 2.—Foraminifera are listed.

Foraminiferi Cretacei delle Marne a Fucoidi di Serramazzoni (Appennino Modenese).—Atti e Mem., Accad. Sci. Lett. Arti di Modena, ser. 5, v. 13, 1955, p. 175-204.—Twenty-eight species, 4 new, and 5 varieties, 1 new, none of them illustrated. A new genus, **Caudammina,** is mentioned.

Variabilità e distribuzione stratigrafica del gen. **Schackoina** Thalmann.—Atti e Mem., Accad. Sci. Lett. Arti di Modena, ser. 5, v. 13, 1955, p. 205-212.—Two species discussed.

Una revisione della Famiglia Heterohelicidae Cushman.—Atti e Mem., Accad. Sci. Lett. Arti di Modena, ser. 5, v. 13, 1955, p. 213-223.

NAGAHAMA, MASAHO. Recent Foraminifera of Suruga Bay (in Japanese with English summary).—Misc. Repts. Research Instit. Nat. Resources, Tokyo, No. 36, Dec. 25, 1954, p. 26-31, text figs. 1, 2 (maps), distrib. table.—Assemblages are divided into several groups corresponding to water masses in the bay.

NEUMANN, M., and BOULANGER, D. Le genre **Fabiana.** Répartition stratigraphique et géographique en Aquitaine.—Bull. Soc. Géol. France, ser. 6, tome 5, fasc. 4-6, 1955 (Jan. 1956), p. 305-310, pl. 18, text fig. 1.—Restricted to top of upper Lutetian.

OBI, K. On the Foraminifera from a boring core in the Tokyo City (in Japanese).—Natural Science and Museums, Tokyo, v. 22, No. 3-5, May 1955, p. 28-31, text figs. 1-3, table 1.—Occurrence of a small fauna (30 species) at 3 levels is recorded.

OKROPIRIDZE, O. V. To the question of supplementary chambers in **Globigerina** (in Russian).—Doklady Akad. Nauk SSSR, Tom. 106, No. 2, 1956, p. 338-341, text figs. 1-4.

OZAKI, HIROSHI. Stratigraphy of the basal conglomerate of the Pliocene Naarai formation in the Tyosi City, Kanto Region.—Bull. Tokyo Nat. Sci. Mus., n. ser., v. 1, No. 2 (No. 35), Sept. 1954, p. 46-61, text figs. 1-5, tables 1-4.—About 50 species are listed.

PAPP, A. Miogypsinidae aus dem Oligozän von Zagorje.—Slovenia, Geologija, Razprove in Porocila, kn. 2, 1954, p. 168-174, pls. 1-3.—Two species, neither one new.

PERCONIG, E. Il Quaternario nella Pianura Padana.—Actes du IV Congrès Internat. Quaternaire, Rome-Pise, 1953, p. 1-36, pls. 1-5 (maps, sections).

Nota informativa sulla presenza del Calabriano nel sottosuolo di Castenedolo (Brescia).—Actes du IV Congrès Internat. Quaternaire, Rome-Pise, 1953, p. 1-11.—Foraminifera are listed.

Due nuove specie di **Uvigerina** del Neogene della Pianura Padana.—Boll. Serv. Geol. Italia, v. 77, fasc. 2-3, 1955, p. 181-198, pls. 1-3.—**Uvigerina longistriata** ranging from Miocene to lower Pliocene and **U. striatissima** ranging from middle to upper Miocene are described. Comparisons are made with 16 other striate species of **Uvigerina.**

Ricerche stratigrafiche e micropaleontologiche nella regione marchigiana (foglio Fermo).—Boll. Serv. Geol. Italia, v. 77, fasc. 2-3, 1955, p. 199-269, pl. 1, text figs. 1-21.—Qualitative and quantitative report on the Foraminifera (about 300 species) from the Helvetian up through the upper Calabrian. Two species (one new) and 3 varieties (one given a new name) are described and illustrated.

PETRI, SETEMBRINO. Fusulinidae do Carbonifero do Rio Tapajos, Estado do Pará.—Bol. Soc. Brasil. Geol., v. 1, No. 1, 1952, p. 30-45, pls. 1, 2, text

fig. 1 (map).—Two Middle Pennsylvanian fusulinids, one new, from northern Brazil.

PETTERS, V., and SARMIENTO S., R. Oligocene and lower Miocene biostratigraphy of the Carmen-Zambrano area, Colombia.—Micropaleontology, v. 2, No. 1, Jan. 1956, p. 7-35, pl. 1, text figs. 1, 2; tables 1-7.—From lower Oligocene to middle Miocene, 7 faunal zones (one divided into 2 subzones) are recognized and correlated with faunal units from other parts of the Caribbean area. Ten new species and one new variety are described. Distribution and abundance of 266 species and varieties are plotted.

POZARYSKI, WLADYSLAW, and WITWICKA, EMILIA. **Globotruncana** of the Upper Cretaceous in central Poland (in Polish with English summary).—Poland Instyt. Geol., Biul. 102, 1956, p. 5-30, pl. 1.—Ranges of 18 species and varieties in Poland are compared with the ranges of the same forms in the Alps and the Caucasus.

RAUZER-CHERNOUSOVA, D. M., et al. Middle Carboniferous fusulinids of the Russian platform and adjoining regions.—Handbook-finder, 1951, 380 p., 58 pls., 30 text figs.—Numerous new species and varieties are described and 4 new genera and 1 new subgenus, all in Russian.

Regional'naia Stratigrafiia SSSR (in Russian).—Akad. Nauk SSSR, Instit. Geol. Nauk, tom 2, 1954.—A volume divided into 4 sections: p. 7-120, pls. 1-21, text figs. 1-14, tables 1-5; p. 121-200, pls. 1-15, text figs. 1-19, table 1; p. 201-254, pls. 1-10, text fig. 1, table 1; p. 255-267, pls. 1-3. The final section, by E. I. CHERNOVA, describes new fusulinids, 6 species and 1 variety.

REISS, Z. Micropaleontology and the Cretaceous-Tertiary boundary in Israel.—Bull. Research Council Israel, v. 5B, No. 1, Sept. 1955, p. 105-120, table.—The age of the **Globigerina** zone that intervenes between Maestrichtian and Paleocene is assumed to be Danian. The major faunal break at the Maestrichtian-Danian boundary indicates the Danian should be included in the Tertiary.

Remarks on the age of some Late Cretaceous and early Tertiary stratigraphic units of Israel.—Bull. Research Council Israel, v. 5B, No. 1, Sept. 1955, p. 121-126, table.—Age determination based on Foraminifera.

RONCHETTI, C. ROSSI. I foraminiferi del deposito elveziano di Dogliani (Cuneo).—Riv. Ital. Pal. Stratig., v. 61, No. 4, 1955, p. 171-180, pls. 14, 15.—Two samples are assigned to the upper Helvetian on the basis of the contained Foraminifera. Species are listed and a few illustrated.

SAGE, NATHANIEL McLEAN JR. The stratigraphy of the Windsor Group in the Antigonish Quadrangles and the Mahone Bay-St. Margaret Bay area, Nova Scotia.—Nova Scotia Dept. Mines, Mem. No. 3, 1954, p. 1-168, pls. 1-21, text figs. 1-14, geol. maps, sections.—Ten species of Foraminifera, none identified beyond genus, are described and illustrated as sketches of thin sections from Mississippian strata.

SAID, RUSHDI, and KENAWY, ABBAS. Upper Cretaceous and lower Tertiary foraminifera from northern Sinai, Egypt.—Micropaleontology, v. 2, No. 2, April 1956, p. 105-173, pls. 1-7, text figs. 1-6.—About 275 species, 46 species and 4 varieties new, recorded and illustrated from 2 sections.

SAURIN, E. Notes paleontologiques sur quelques calcaires a fusulinides du Nord Viet-Nam.—Archives Géol. Viet-Nam, No. 1, 1953 (1954), p. 1-30, pls. 1-5.—Twenty-nine species of fusulinids of which 1 is new, 2 are given new names, and 6 are indeterminate, are described and illustrated from Permian strata.

SHEPARD, FRANCIS P., and MOORE, DAVID G. Central Texas coast sedimentation: characteristics of sedimentary environment, recent history and diagenesis.—Am. Assoc. Petroleum Geologists Bull., v. 39, no. 8, 1955, p. 1463-1593, text figs. 1-75.—Facies are characterized in part by Foraminifera.

SIGAL, JACQUES. Notes micropaleontologiques nord-africaines. 4, **Biticinella breggiensis** (Gandolfi), nouveau morphogenre. 5, A propos de **Globotruncana helvetica** Bolli.—C. R. S. Soc. Géol. France, No. 3, Feb. 6, 1956, p. 35-37, 1 text fig.

STEWART, R. E. Stratigraphic implications of some Cenozoic Foraminifera from western Oregon (to be continued).—The Ore-Bin, v. 18, No. 1, Jan. 1956, p. 1-6, text fig. 1, index map.—Lists of species as recorded from Pleistocene, Pliocene, and Miocene formations.

TAI, YOSHIRO. Micropaleontological study of the Furue formation—Geology of the Tertiary system in Shimane Peninsula, Japan (Part 3).—Journ. Geol. Soc. Japan, v. 61, No. 720, Sept. 1955, p. 407-420, text figs. 1, 2, tables, maps, columnar sections.—Quantitative distribution of about 60 species is recorded. Two new species are described.

TAMAJO, ELEONORA. Su alcune "Breccie argillose" della sicilia.—Boll. Serv. Geol. Italia, v. 76, fasc. 2, Anno 1954, 1955, p. 345-361, text fig. 1.—Includes many lists of Foraminifera.

THALMANN, HANS E. Bibliography and index to new genera, species, and varieties of Foraminifera for the year 1954.—Journ. Pal., v. 30, No. 2, March 1956, p. 352-388.

THOMPSON, M. L., and ZELLER, DORIS NADINE. **Profusulinella** in western Utah.—Journ. Pal., v. 30, No. 2, March 1956, p. 333-337, pl. 44, text fig. 1.—One already-known species recorded and illustrated.

TODD, RUTH, and BLACKMON, PAUL. Calcite and aragonite in Foraminifera.—Journ. Pal., v. 30, No. 1, Jan. 1956, p. 217-219.

TORRENTE, ANTONIO. Nota preliminare sul rilevamento nel 1° quadrante del Foglio Larino (Abruzzo).—Boll. Serv. Geol. Italia, v. 76, fasc. 2, Anno 1954, 1955, p. 595-600, distrib. chart.—Ranges of numerous species in a section of lower and upper Pliocene.

WHITE, WILLIAM R. Pliocene and Miocene Foraminifera from the Capistrano formation, Orange County, California.—Journ. Pal., v. 30, No. 2, March 1956, p. 237-260, pls. 27-32, text figs. 1, 2, tables 1-3.—Fifty-nine species and varieties, 2 species and 4 varieties new and one new name, indicate upper Mohnian stage of the Miocene for the lower part of the Capistrano formation and equivalence with upper Repetto formation (lower Pliocene) for the upper part of the Capistrano formation.

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RUTH TODD

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